

World Premier International Research Center Initiative (WPI)

FY 2017 WPI Project Progress Report

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Common instructions:

* Unless otherwise specified, prepare this report from the timeline of 31 March 2018.

* So as to base this fiscal year's follow-up review on the "last" center project, please prepare this report from the perspective of the latest project plan.

* Use yen (¥) when writing monetary amounts in the report. If an exchange rate is used to calculate the yen amount, give the rate.

* Please prepare this report within 10-20 pages (excluding the appendices, and including Summary of State of WPI Center Project Progress (within 2 pages)).

Summary of State of WPI Center Project Progress (write within 2 pages)

Research Highlights

This is our first report from the 5-year extension period of the WPI funding for which we have added 9 new challenges, as listed later in the body of the report. Among them, the first 4 are directly related to research. Here let us first summarize research highlights in accordance with their relevance to those 4 challenges.

(1) create new areas and tools of statistics, integrating mathematics with observation and experiments:

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

(2) create new synergies among fields not imagined at the launch:

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

(3) discover new major framework for geometric thinking in mathematics and physics with the derived and non-commutative geometry, such as to unify various types of dualities:

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

(4) executing projects successfully to produce world-competitive results on dark energy, dark matter, and inflation:

- The Hyper Suprime-Cam (HSC) members published 40 papers for their research achievements in the HSC special issue of the peer reviewed journal Publications of the Astronomical Society of Japan in January 2018. The science team of the collaboration was led by M. Takada. The HSC Weak Lensing Working Group built the catalog of galaxy shapes from the high-quality, high-resolution HSC images for 10 millions galaxies. Kavli Associate Scientist M. Oguri used the weak lensing

measurement to reconstruct 2- and 3-dimensional maps of dark matter over an unprecedented area and spatial resolution. PFS, the multi-fiber spectrograph for Subaru to follow up HSC imaging survey, fully completed the mass production of 2550 fiber positioners. The metrology camera will be installed soon. The science observation is expected to start in 2021.

- XMASS updated the annual modulation search for low mass WIMPs using 2.7 years data. XMASS also improved the upper limits at about one order of magnitude by searching for two-neutrino double electron capture on ^{124}Xe and ^{126}Xe . XMASS presented the first experimental result for Kaluza-Klein axions and set an upper bound for the axion coupling constant.

- T2K furthered the world leading search for CP violation in neutrino and antineutrino oscillations. Kavli IPMU member M. Hartz was chosen among the 500+ member international collaboration to make the first presentation of T2K results at a KEK colloquium and press conference, showing that the T2K data disfavor absence of CP violation at a 95% confidence level.

- LiteBIRD, our leading satellite mission searching for primordial gravitational waves produced during the cosmic inflation era, has now progressed to the JAXA/ISAS Phase A1 and has been selected as a top-priority large-scale project "Master Plan 2017" by the Science Council of Japan. The LiteBIRD team extends the collaboration in different fields and also in master and doctor students.

Scientific research progress

In the calendar year (CY) 2017, 304 (392 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, 450 in CY2016 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 CY2017, the rate of highly cited papers "top 1% of papers" is 20 (5.1%) based on the Web of Science by Clarivate Analytics. The impact factor for all of our refereed papers published from the institute's inception to Dec 2017 are as follows: the average number of citations per paper is 26.4; 112 papers have over 100 citations and 366 over 50 citations in which review papers are excluded. The fraction of CY2017 papers with international collaboration reaches 78%. The Kavli IPMU members also received 10 valuable prizes/awards and honorary titles during FY2017.

Interdisciplinary studies

We held interdisciplinary seminars, 74 math-string (MS) seminars and 94 Astronomy-Particle physics-Experimental physics-Cosmology (APEC) seminars, among 192 seminars in FY2017. Prof. H. Yokoyama, a new female professor majoring in Science Communication and Policy, acts as a catalyst between the Interfaculty Initiative in Information Studies by accepting PhD students. T. Melia, a new assistant professor at the Kavli IPMU, conducted a number of works on particle physics using advanced mathematics. We hired a joint postdoc with the Institute for Solid State Physics and conducted joint seminars occasionally. A. Tsuboi held the 1st Kavli IPMU Artist in Residence Program Artist Exhibition "reⁿ-Encounter between Science and Art 2018" for advancing fusion of art and science.

Globalization

The ratio of non-Japanese members among all of researchers is 41%. During FY2017, we had 738 (938) visitors (the numbers in the parentheses take into account multiple visits). Among them, 436 (510) were international. We hosted 11 conferences and workshops where 236 were from foreign institutions among 672 participants. We obtained 657 applicants for our postdoctoral positions and 90% of them were from outside Japan. So far the Kavli IPMU has signed 20 cooperative research agreements or memoranda of understanding (MOU), with three new research agreements with the Kavli Institute for Astronomy and Astrophysics at Peking University (KIAA), le Centre National de la Recherche Scientifique (CNRS), and the Mainz Institute for Theoretical Physics (MITP).

Organizational Reform

Kavli IPMU administrative staff members were awarded the 2017 Special Prize for Business Transformation by developing an education video in English to prevent harassment together with the University Harassment Counseling Center. This is the fifth time staff received this award following on from 2008, 2013, 2015 and 2016. Many of our successful system reforms have now spread over the rest of the University and propagated to other research institutions to help boost the overall competitiveness of Japan on a global scale.

Others

H. Murayama received a Research Award from the Alexander von Humboldt Foundation in Germany in recognition of giving a significant impact on relevant academic fields. We successfully recruited two new female faculty professors: Prof. H. Yokoyama who specializes in Science Communication and Policy and Prof. Y. Ito, a mathematician in Algebraic Geometry as a cross-appointment with the Nagoya U. Y.-K. Kim was elected to American Academy of Arts and Science. H. Ooguri was elected to the Japan Writers' Association. He published a new book titled as "Quest to the Truth – Dialogue between Buddhism and Astrophysics". Hamamatsu Photonics K.K. was awarded the U Tokyo, Shokumon Award in recognition of establishing the first endowed professorship for fundamental

science and their support for Kavli IPMU research into the Dark side of the universe.

* Please describe clearly and concisely the progress being made by the WPI center project from the viewpoints below.

- In addressing the below-listed 1-6 criteria, please place emphasis on the following:

- (1) Whether research is being carried out at a top world-level (including whether research advances are being made by fusing fields).
- (2) Whether a proactive effort continues to be made to establish itself as a "truly" world premier international research center.
- (3) Whether a steadfast effort is being made to secure the center's future development over the mid- to long-term.

This is our first report from the 5-year extension period of the WPI funding. In addition to the five major questions that we proposed to address back in 2007, we have proposed the following 9 challenges in the extension period addressing new objectives. In the first year of the extension period, we started to take action to realize the following 9 challenges. The progress is denoted as [(X) of 9 challenges].

- (1) create new areas and tools of statistics, integrating mathematics with observation and experiments;
- (2) create new synergies among the fields not imagined at the launch; and
- (3) discover new major framework for geometric thinking in mathematics and physics with the derived and non-commutative geometry, e.g., to unify various types of dualities.

We will achieve these goals building on the initial success by

- (4) executing projects successfully to produce world-competitive results on dark energy, dark matter, and inflation; and
- (5) attracting and retaining the best and broadly minded scientists from around the world.

Concerning the system reform, we take up challenge

- (6) to bring successful system reforms to the rest of the University and other research institutions to help boost the overall competitiveness of Japan on a global scale;
- (7) to make a serious attempt to create a new international graduate program with vigorous student exchanges;
- (8) to enlarge the force for outreach to young students, by organizing workshops for scientists and high school teachers; and
- (9) to attain sufficient stability of the organization so that we can bring our research objectives beyond the WPI funding.

We structure this report according to the five major questions as before, but we will make it clear how our progress addresses these nine challenges.

1. Conducting research of the highest world level

* Regarding the criteria used when evaluating the world level of center, please note any updated results using your previous evaluation criteria and methods or any improvements you have made to those criteria and methods.

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 started, 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. Below we describe the research progress in 2017 related to each question.

How did the Universe start?

Early Universe (inflation, baryogenesis, symmetry breaking): H. Fukuda, M. Ibe, M. Suzuki and T. Yanagida proposed a simple prescription which provides an origin of the Pecci-Quinn (PQ) symmetry [Phys. Lett. B771 (2017) 327]. In this prescription, the global U(1) PQ symmetry is virtually embedded in a gauged U(1) PQ symmetry. R. Alonso, P. Cox, C. Han and T. Yanagida consider a flavoured B - L gauge symmetry under which only the third generation fermions are charged. Such a symmetry can survive at low energies (\sim TeV) while still allowing for two superheavy right-handed neutrinos, consistent with neutrino masses via see-saw and leptogenesis. They describe a mechanism for generating Yukawa couplings in this model and also discuss the low-energy phenomenology. Interestingly, the new gauge boson could explain the recent hints of lepton

universality violation found at LHCb, with a gauge coupling that remains perturbative up to the Planck scale [Phys. Lett. B774 (2017) 643].

Primordial black holes (PBHs) are one of the candidates to explain the gravitational wave (GW) signals observed by the LIGO detectors. Among several phenomena in the early universe, cosmic inflation is a major example to generate PBHs from large primordial density perturbations. K. Inomata, M. Kawasaki, K. Mukaida, Y. Toda and T. Yanagida discussed the possibility to interpret the observed GW events as mergers of PBHs that are produced by cosmic inflation. The primordial curvature perturbation should be large enough to produce a sizable amount of PBHs, and thus we have several other probes to test this scenario including pulsar timing array experiments [Phys. Rev. D95 (2017) 123510]. String theorists T. Watari, M. Yamazaki and a phenomenologist Y. Nomura also published a paper about natural inflation. B. Thorn from Oxford University has left for Princeton after his nearly one year visit at the Kavli IPMU. He published a paper about the chiral gravitational wave background of an axion-SU(2) inflationary model [Phys. Rev. D97 (2018) 043506], and he will complete his PhD at Princeton in the remaining time of his program.

CMB experiments (POLARBEAR, Simons Observatory, LiteBIRD): The CMB members at the Kavli IPMU have now evolved into 4 faculties and 4 postdocs working on the simulation, analysis and experiment for POLARBEAR, LiteBIRD, and more. F. Matsuda (project researcher) from UC San Diego is joined the group to work on POLARBEAR and the Simons Observatory. Also, T. Ghigna from Oxford University joined the group through the exchange program between Oxford and the Kavli IPMU, and he will be with us for the next two years. D. Kaneko is playing a leading role in the preparation toward the deployment of POLARBEAR2, which is scheduled in 2018. The receiver, including the cryogenically cooled optics and the superconducting detector array, is integrated at KEK, and the final verification tests are in progress.

The satellite mission, LiteBIRD, is now in the JAXA/ISAS Phase A1. Y. Sakurai is leading the effort to develop the polarization modulator for LiteBIRD, which is the key instrument to probe the large angular scale CMB B-mode. M. Hazumi, the PI of LiteBIRD, is leading the international collaboration. In addition to the current Japanese and the US collaborations, cosmologists from Europe have been organized to prepare participating in LiteBIRD. N. Katayama, H. Sugai, and T. Matsumura coordinate this worldwide effort on foreground removal and calibration strategy. The characterization of the transition edge sensor bolometer, which is fabricated at UC Berkeley, has started. T. Ghigna is leading the detector characterization that is carried out at 100 mK in the Kavli IPMU lab B, i.e. the coldest spot in the Kavli IPMU building. They expanded the collaborations such that master and doctoral students, K. Komatsu (Okayama Univ.), S. Sugiyama (Saitama Univ.), H. Ochi (Yokohama National Univ.), and R. Takaku (Univ. of Tokyo) are actively carrying out the experiment at the Kavli IPMU.

In addition to POLARBEAR and LiteBIRD, the activity for the next generation ground-based project, Simons Observatory, has also started. A dedicated test cryostat has arrived, and correspondingly the lab to support all of these activities has expanded. In addition to the lab B at the Kavli IPMU, we now have three additional lab spaces to carry out experiments in Kashiwa campus. We can now use liquid helium in Kavli IPMU building and also installed a numerically controlled milling machining for in-house production for mechanical parts ([4] of 9 challenges).

What is the Universe made of?

Dark Matter: The nature of dark matter is one of the utmost important questions, especially because it gave birth to stars and galaxies we observe today, and hence our existence as well. H. Murayama proposed a novel paradigm that dark matter is not a single particle nor elementary, as commonly assumed, but consists rather of bound states in “dark QCD,” akin to pions in the strong interactions in the Standard Model (top 1% paper in all physics in 2015). Together with international collaborators, H. Murayama extended the theory when the dark matter particle has spin one, with novel experimental signatures [JHEP 1710 (2017) 162]. He also showed that many theories can be tested at low-energy electron-positron colliders such as SuperKEKB with information on spectroscopy of bound states [Phys. Rev. D97 (2018) 055030]. It represents synergistic research between theoretical and experimental physics.

Particle phenomenological research at the Kavli IPMU in FY 2017 was devoted to chart future direction of the field by proposing novel experimental principles as well as constructing new physics models. For instance, H. Fukuda, S. Matsumoto and T. Yanagida proposed a novel idea to detect ultralight dark matter utilizing astronomical ephemerides, where the scattering of dark matter off solar system bodies acts as a resistance force opposing their motions. S. Matsumoto, M. Takeuchi, and S. Shirai proposed a new search strategy for weakly interacting dark matter at LHC (arXiv:1711.05449). Precision measurements of the Standard Model processes can reveal quantum effects of the dark matter. This indirect probe will be as powerful as conventional dark matter searches based on missing energy. M. Takeuchi provided a realistic estimate of the sensitivity for the Higgs self-coupling at a future HE-LHC (27 TeV) and 100 TeV collider using the di-Higgs production channel with D. Goncalves, T. Han, F. Kling and T. Plehn (arXiv:1802.04319). They found it reaches O(10%) accuracy at 27TeV and will provide the information on whether the electro weak phase transition is 1st order or not. T. Yanagida, P. Cox and C. Han proposed a model to explain the recently reported B decay anomaly [Phys. Lett. B774 (2017) 64], where dark matter could also be explained by the same model [JCAP1801 (2018) 29].

XMASS: In FY 2017, multiple new results were obtained. A search was done for solar Kaluza-Klein axions. They are supposed to be trapped in the solar system and expected to decay into 2-photons and be possibly observed by terrestrial detectors like XMASS. No positive signals were found and an upper bound was set for the axion coupling constant and the number density of such particles [PTEP 103C01, 2017]. This is the first experimental result for such particles. XMASS team has submitted two papers updating the previous published results. A modulation search for low mass WIMPs was performed with the increased data covering 2.7 years. Small enhancement of the modulation amplitude seen in the first paper was found to be less significant (arXiv:1801.10096). The team has improved the search for two-neutrino double electron capture on ^{124}Xe and ^{126}Xe where newly developed electron/gamma separation method were applied and the upper limits have improved by about one order of magnitude (arXiv:1801.03251). XMASS will stop data taking at the end of 2018. All Kavli IPMU members in the current XMASS collaboration have decided to join XENON-nT, the two-phase liquid xenon dark matter experiment, and were accepted ([4] of 9 challenges).

What is the fate of the Universe?

SuMIRe (HSC and PFS): SuMIRe (Subaru Measurement of Image and Redshifts) is a large-scale international survey project aiming at uncovering the origin and future of the universe led by the Kavli IPMU. A wide-field imaging camera Hyper Suprime-Cam (HSC), the new 900M-pixel digital camera for Subaru Telescope, is one of the two subprojects of SuMIRe. An international team including scientists in Japan, Taiwan and Princeton University has been carrying out a large-scale imaging survey of the sky with the Subaru HSC since 2014. The Kavli IPMU contributed to more than a half of the HSC instrument, including the wide-field corrector lens, precision mechanical control, and some of the filters, and leads the science team. The team used multi-color data from the first two years to carry out research in a broad range of topics including the search for new objects in the solar system, the search for dwarf galaxies in the Milky Way, studies about galaxies and quasi-stellar objects (QSOs) hosting supermassive blackholes, the search for highest-redshift galaxies, and dark matter distribution in the Universe. The HSC Science Working Group co-chairs, M. Takada (Kavli IPMU) and M. Strauss (Princeton), coordinated the team to publish 40 papers for these research achievements in the HSC special issue of the peer reviewed journal, the Publications of the Astronomical Society of Japan [PASJ, Vol 70 (2018) Issue SP1]. One of the major results is that the HSC Weak Lensing Working Group built a catalog of galaxy shapes from the high-quality, high-resolution HSC images for 10 millions galaxies, using a sophisticated data analysis pipeline and detailed image simulations of galaxies combining the Hubble Space Telescope data and the HSC data [R. Mandelbaum, H. Miyatake *et al.*, PASJ 70 (2018) S25]. This catalog of galaxy shapes enables us to measure weak gravitational lensing effects on shapes of galaxies that are caused by an inhomogeneous distribution of dark matter in the Universe. As one of the weak lensing science achievements, the team led by Kavli Associate Scientist M. Oguri used the weak lensing measurement to reconstruct 2- and 3-dimensional maps of dark matter over an unprecedented area with an unprecedented spatial resolution. One dimension of the 3-dimensional map is a time direction, and therefore it reveals the time evolution of dark matter distribution in the Universe over

8 billions years in the cosmic history [PASJ 70 (2018) S26]. The team is now working very hard on the weak lensing measurements to estimate cosmological parameters including the parameters of dark energy, and will report the results within one year.

On the other hand, we also have made progress in another subproject of SuMiRe, a wide-field multi-object spectrograph, Prime Focus Spectrograph (PFS), aimed at making the spectroscopic follow-up of HSC images. This project is being led by H. Murayama as the principal investigator researcher (PI), the science group co-leader M. Takada, and the project manager N. Tamura, all at the Kavli IPMU, involving an interdisciplinary group that consists of both physicists and astronomers from the Academia Sinica Institute for Astronomy and Astrophysics (ASIAA, Taiwan), Jet Propulsion Laboratory of NASA, the California Institute for Technology, Princeton University, Johns Hopkins University, Laboratoire d'Astrophysique de Marseille (LAM), Universidad São Paulo, the Laboratório Nacional de Astrofísica (LNA, Brazil), the Max Planck Institutes for Astrophysics, and for Extraterrestrial Physics, and the PFS Chinese consortium. The construction of the PFS instrument is well underway. All 2550 fiber positioners, "Cobra", were delivered. The team at the California Institute for Technology Jet Propulsion Laboratory (Caltech/JPL) are integrating "Cobra modules" each of which consists of 57 Cobras to move the fiber tips to astronomical targets on the focal plane. All science-grade detectors in optical and infrared wavelengths were also delivered. The team is now carrying out various tests on the spectrograph modules such as image quality and thermal performance in the integration hall at LAM. Kavli IPMU scientist, Y. Moritani, is leading the team to make detailed plans to carry out on-site tests of the performance and on-sky commissioning observations at the summit of Mauna Kea with the PFS installed on the Subaru telescope. Kavli IPMU scientist, K. Yabe, is also leading the team to develop software to estimate an expected spectrum of each astronomical object with PFS, as well as to simulate a 300 Subaru-night PFS survey in detail including the planned science programs. We envision that we can start science operation in 2021, spending more than or equal to 300 nights of Subaru Telescope. The combination of HSC and PFS is unique in the world and will enable us to examine the nature of dark matter and dark energy, the evolution and origin of galaxies and the assembly history of the Milky Way, Andromeda Galaxy, and the Local Group as a whole [(4) of 9 challenges].

Supernovae: Superluminous Supernovae (SLSNe) are extra bright types of supernovae discovered in the last decade that is 10 to 100 times brighter than ordinary supernovae, but no one could explain what explosion mechanism could produce the extraordinary UV-bright emission that SLSNe have. Kavli IPMU astronomers A. Tolstov, A. Zhiglo, K. Nomoto and his colleagues discovered that ultraviolet light from SLSNe has key information to reveal the explosion mechanism [Astrophys.J. 845 (2017) L2].

Type Ia supernovae are used in astronomy as a reference point when calculating distances of objects in space. However, no one has been able to find solid evidence of what triggers these explosions. An international team including K. Nomoto, N. Yasuda and N. Suzuki found evidence of a supernova explosion that was first triggered by a helium detonation [Nature 550 (2017) 80].

Formation of Black Holes: Recent discoveries of the super-massive black holes located 13 billion light years away, corresponding to when the universe was just five percent of its present age, pose a serious challenge to the theory of black hole formation and evolution. The physical mechanisms that form black holes and drive their growth are poorly understood. N. Yoshida and his collaborators have successfully used a supercomputer simulation to recreate the formation of a massive black hole from supersonic gas streams left over from the Big Bang. Their study shows this black hole could be the source of the birth and development of the largest and oldest super-massive black holes recorded in our Universe [Science 357 (2017) 1375].

What are its fundamental laws?

Quantum Gravity: Y. Tachikawa conducted his research on quantum field theories (QFTs), mainly concerning the effect of the so-called "quantum anomaly". A QFT is said to have an anomaly when the phase of its partition function has a subtle ambiguity which can be controlled by the methods of topology. Although the study of QFTs with anomaly in high energy physics is an old subject, it is now actively being revisited because of its relation to the research of the topological materials in condensed matter physics. More concretely, in a paper with I. Garcia-Etxebarria, H. Hayashi, K.

Ohmori, K. Yonekura, he studied the anomalies in 8-dimensional supersymmetric gauge theories in general, and uncovered a hitherto-neglected gauge anomaly in the case of the symplectic gauge group which must be canceled by a topological version of the Green-Schwarz mechanism [JHEP 1711 (2017) 177]. In another work, in a paper with K. Yonekura, he studied a new type of anomalies associated to the space of coupling constants of the theory [JHEP 1712 (2017) 140]. Y. Tachikawa gave an invited series of introductory lectures on this topic at CERN and at Rikkyo University [(3) of 9 challenges].

String theory: K. Hori showed that the boundary degrees of freedom in 2-dimensional gauge theories form flat projective representations of the gauge group, of the type determined by the theta angle. This generalizes what was found by M. Douglas on theories with finite gauge groups (orbifolds with discrete torsion) to theories with general compact gauge groups. K. Hori then applied the result to (2,2) supersymmetric gauge theories and obtained a set of allowed projective representations on the boundary, when the matter content satisfies a certain condition (called "symmetric"). The set agrees with the one found by mathematicians Š. Špenko and M. Van den Bergh that determines the categorical resolutions of quotient singularities, which is an important problem in algebraic geometry [(3) of 9 challenges].

T. Watari published a paper with a Ph.D student at the Kavli IPMU, K. Kanno. So long as they follow the current understanding of string theory, it is known that supersymmetric compactification of Type IIB string theory with fluxes leads to gravitino mass that is much higher than TeV scale, and this prediction does not fit very well with the supersymmetric gauge coupling unification of the Standard Model [Phys. Rev. D96 (2017) 106001]. The only known idea (other than accidental fine tuning) to reconcile these two observations is the one by O. DeWolfe *et al.* in 2005, which hints that the internal manifold with some arithmetic properties may have something to do with the small value of gravitino mass. T. Watari and K. Kanno revisited this idea and explored mathematical background. They discovered that the idea by DeWolfe *et al.* in 2005 works much better, when the internal manifold is of CM-type (an arithmetic property generalizing "complex multiplication").

Effective Field Theory: To understand what physics lies beyond the Standard Model, it is imperative to have a complete yet non-redundant parameterization of its impact on precision measurements, which eluded the community for more than a quarter of century. H. Murayama proposed a well-defined algorithm [JHEP 1708 (2017) 016] together with members of the Kavli IPMU Berkeley satellite, B. Henning, X. Lu, T. Melia (now our new assistant professor), with 50 citations in a short amount of time. The group published more details of the formalism to help with the community, and extended it to non-renormalizable theories such as chiral Lagrangians [JHEP 1710 (2017) 199]. It employs infinite-dimensional representations of the conformal group that extends the traditional mathematical theory of invariants by Hilbert, Wigner and Weyl.

Mathematics: M. Kapranov (with M. Finkelberg and V. Schechtman) has given a combinatorial description of the Fourier-Sato transform and related functors on perverse sheaves which are smooth with respect to a real hyperplane arrangement (arXiv:1712.07432). M. Kapranov (with A. Bondal and V. Schechtman) further has determined the global invariants of perverse sheaves associated to flops in birational geometry (arXiv:1801.08286).

T. Milanov has completed two projects during 2017. The first one compares the notion of a semi-simple Frobenius manifold and the so-called Eynard-Orantin recursion. He has developed a technique based on the theory of primitive forms that allows him to determine whether the correlation functions defined by a given Eynard-Orantin recursion correspond to the correlators defined by a semi-simple Frobenius manifold. The text is available on arXiv:1701.00393 (submitted to Annales de l'institut Fourier). In the second project he formulated a general problem of inverting the period map defined via the second structure connection of a semi-simple Frobenius manifold. His motivation comes from his earlier work with B. Bakalov on W -constraints for simple singularities. The problem can be viewed as a first step to generalize their work with B. Bakalov to more complicated singularities. He was able to solve this problem in the case of the quantum cohomology of the projective plane. The paper is available on-line arXiv:1706.04323 (submitted to Advances in Mathematics).

T. Kobayashi developed his mathematical program proposed in 2015 on branching laws of infinite-dimensional representations. In particular, he established a complete classification of conformally covariant and symmetry breaking operators for differential forms on the model space, published with B. Speh a paper of about 280 pages (arXiv: 1801.00158). Applications include topics on the Gross-Prasad conjecture in automorphic forms. Furthermore, with Y. Benoist, he proved a necessary and sufficient condition on G-real varieties X for the unitary representation $L^2(X)$ to be tempered (arXiv: 1706.10131).

T. Kohno developed a theory of holonomy representations and their higher category extension. By means of a 2-functor from the path 2-groupoid of the configuration space, he constructed representations of the 2-category of braid cobordisms. More generally, he developed a method to construct higher category extension of holonomy representations of homotopy path groupoid by means of Chen's formal homology connection. Using this method, he investigated categorification of Knizhnik-Zamolodchikov (KZ) connections.

Y. Toda developed a mathematical theory of Gopakumar-Vafa invariants, developed by physicists, and proposed with another mathematician D. Maulik in 2016. The main result is to show that the Gopakumar-Vafa invariants are independent of stability conditions (arXiv:1710.01843), which also implies the flop invariance of these invariants. The key ingredient is to use the analytic neighborhood theorem for moduli stacks of semistable sheaves proved in another paper (arXiv:1710.01841).

It is observed by A. Beilinson that the epsilon factor formalism best fits into the homotopical framework, and he established the theory for Betti cohomology. Taking this view point into account, T. Abe is trying to establish an l-adic analogue of the theory. An issue comes in when we consider non-isolated characteristic functions. T. Abe formulated the question as a conjecture, and is in progress to solve the conjecture. In order to treat this, T. Abe realized that one needs to work in Zariski-Riemann space, using a technique of K.S. Kedlaya.

All of the mathematical works are concerned with (3) of 9 challenges.

Why do we exist?

KamLAND-Zen: Neutrinoless double beta decay is one of the clues to solve the mystery: why is our Universe made of matter? Or why does almost no antimatter exist in our Universe? KamLAND-Zen is an experiment to search for neutrinoless double beta decay in Xenon 136 and its detector is located 1000m underground in the Kamioka mine. The international team led by K. Inoue (PI of the Kavli IPMU and also Director of the Research Center for Neutrino Science, Tohoku University) including A. Kozlov holds the world best limit for the effective Majorana neutrino mass and the limit excludes most of the degenerated mass hierarchy region. The team is going to extend the sensitivity to exclude the entire inverted mass hierarchy region and has produced the key instruments of bigger mini-balloon for the purpose in the world cleanest environment. The expected sensitivity covers the effective mass predicted by Yanagida's model and another Hamaguchi's model [(4) of 9 challenges].

T2K: The T2K experiment is probing neutrino oscillations by studying the properties of neutrinos and antineutrinos produced at the J-PARC accelerator and detecting them 295 km away in the Super-Kamiokande (SK) detector. The main physics objective of T2K is to compare the rate of muon neutrino to electron neutrino oscillations with its anti-matter counterpart. Observing a difference in this oscillation rate for neutrinos and antineutrinos would be the first evidence of CP violation in the lepton sector. With data collected through May 2017, T2K doubled the amount of its neutrino data set. T2K also improved the reconstruction and selection of events in SK, increasing the experimental sensitivity by 30%. Based on the new data and analysis improvements, T2K made a world leading search for CP violation in neutrino and antineutrino oscillations. Kavli IPMU member M. Hartz was chosen among the 500+ member international collaboration to make the first presentation of these results at a KEK colloquium and press conference, showing that the T2K data disfavors absence of CP violation at a 95% confidence level. T2K resumed collecting data in October 2017 and expects to double the amount of antineutrino data on hand by May 2018, further improving the sensitivity to CP violation in neutrino oscillations. Kavli IPMU members M. Hartz and B. Quilain are leading the data analysis efforts for T2K. Kavli IPMU graduate student T. Vladislavjevic from Oxford has recently

completed an improved calculation of the T2K neutrino and antineutrino fluxes using external experimental data. This improved calculation will reduce the uncertainty on the flux estimates by a factor of two. With new data and improvements to analysis techniques, T2K will remain a leader in the experimental neutrino physics and the search for CP violation in the lepton sector [(4) of 9 challenges].

Belle II: The Kavli IPMU is a collaborating institute of the Belle II experiment at KEK, Japan, which is a high-energy electron-positron collider experiment searching for new physics beyond the Standard Model of particle physics. The Belle II detector is located at the electron-positron collision point, and the silicon vertex detector (SVD) will be installed at the next center of the Belle II detector to the pixel detector. The SVD consists of cylindrical arrangements of sensor arrays (ladders) in a four-layer structure, and the outermost layer comprises of sixteen ladders. Kavli IPMU members of Belle II are responsible for the assembly of sixteen ladders plus four spare ladders. They established the assembly and qualification procedures of the ladders in the Kavli IPMU clean room, and by March 2016 they had finalized it by confirming a mechanically and electrically good quality prototype ladder. The next challenge was mass production of the twenty ladders that had good quality like the prototype ladder. They had started off the mass production in May 2016, and produced ladders throughout 2017. They produced five ladders in 2016, excluding ladders lost due to parts or production fault; they doubled the production speed by successfully streamlining the ladder assembly procedure, and they produced twelve ladders this year. By January 2018, eight of our ladders have already been mounted on the SVD supporting structure. They will finalize the ladder mass production by early summer this year. The completion of ladder mounting of all our ladders will be completed in a similar period [(4) of 9 challenges].

EGADS: EGADS (Evaluating Gadolinium's Action of Detector Systems) is a 200-ton scale model of Super-Kamiokande (SK), which is 50,000-ton scale, enriched with 0.2% gadolinium sulfate in order to make neutron captures visible. It operated stably between April 2015 and October 2017. During that period the water in the tank was completely recirculated over 650 times, with no detectable loss of gadolinium, while its transparency remained as good as that of the ultrapure water in SK. In October 2017 the EGADS tank was drained and a careful internal inspection was performed. After 2.5 years of exposure to Gd-loaded water, the detector components were just as shiny and clean as they had been in 2015, and had experienced no ill effects whatsoever.

As a result of these EGADS studies, both the SK and T2K Collaborations officially endorsed and approved the Kavli IPMU-originated and Kavli IPMU-developed concept of loading SK with gadolinium, known as GADZOOKS! (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!). They also agreed upon the start date for this new phase of operations, formally known as SK-Gd: the in-tank work needed to get SK ready for Gd loading will begin on June 1st, 2018. This is the first time SK will have been opened since 2006. It is expected that the first gadolinium will then go into the tank in 2019.

Since the R&D phase of gadolinium is now finished, the refilled EGADS has been repurposed into a supernova neutrino detector and its acronym redefined to "Employing Gadolinium to Autonomously Detect Supernovae". Its online computing power has been significantly improved, with the goal of sending a fully automated alert to the astronomical community within one second of the arrival of the first neutrino from an explosion anywhere in our galaxy. This will be possible due to the unique signature of supernova neutrinos in the presence of gadolinium. EGADS will also serve as Kavli IPMU and Institute for Cosmic Ray Research (ICRR)'s backup supernova neutrino detector while SK is offline for refurbishment during the remainder of 2018 [(4) of 9 challenges].

2. Advancing fusion of various research fields

A JST CREST project "Statistical Computational Cosmology" is aimed at developing fast imaging data analysis applications for the Subaru HSC survey. In 2017, the project members developed a deep convolutional neural-network that performs multi-label classification of supernovae (A. Kimura *et al.* 2017, IEEE). The classifier has been successfully installed and a number of distant Type Ia supernovae with redshifts greater than 1 were identified. They also developed a machine-learning strong lensing estimator. Its performance and the accuracy of the lens mass and ellipticity prediction have been examined. They will test the machine using real strong lensing images obtained from the

HSC survey [(1) of 9 challenges].

In collaboration with B. Henning, in work to appear soon, T. Melia discovered a technique to systematically construct conformal primary operators of any spin in low spacetime dimensions. This complements the results of a series of papers in the past two years published in collaboration with B. Henning, X. Lu, and H. Murayama, which identified conformal primary operators as those which span the operator basis of an effective field theory. This work paves the way to a systematic theoretical study of the effects of higher dimension operators, as is relevant for experimental searches for new physics at for example, the Large Hadron Collider, or the proposed International Linear Collider in Japan. In another project, T. Melia developed an idea to use a chemical crystal as a particle - in particular dark matter - detector. This involved collaborative work with P. Bunting (a chemist), G. Gratta (an experimentalist) as well as theorist S. Rajendran [Phys. Rev. D95 (2017) 095001]. In January, T. Melia organized the workshop "Berkeley Week at Kavli IPMU", which explored topics at the interface of particle and cosmological physics phenomenology, and encouraged collaborative work between members of the Kavli IPMU and the UC Berkeley physics department [(2) of 9 challenges].

The Kavli IPMU and the Japan Aerospace Exploration Agency's (JAXA) Institute of Space and Astronautical Science (ISAS) started a new collaboration to apply their work in artificial satellites, particularly in developing hard X-ray and gamma ray detectors, to biomedical research. Both X-ray and gamma rays are valuable to researchers studying particles, the basic ingredients of everything in the Universe, but they are also useful in everyday life because they allow humans to see inside objects or people. Researchers at the Kavli IPMU and ISAS/JAXA will work together with the Keio University School of Medicine to transfer their technology to nuclear medicine. They aim to see the location of cancer stem cells with a 100 μ m accuracy, and to push forward research in cancer treatment. We succeeded in attracting T. Takahashi, a former professor in JAXA, as a new professor at the Kavli IPMU and the collaboration will be based at the Kavli IPMU. This work is concerned with (2) of 9 challenges, and demonstrates the application of fundamental science to medical research.

H. Yokoyama, a new Kavli IPMU professor, and Dr. Y. Ikkatai, who specializes in science policy and communication, studied science crowdfunding (CF) and clarified the differences with the conventional mechanism of science funding (Journal of Information Processing and Management 2017, Vol.60, No.9, p.666). Most of conventional science funding supported by the government is peer-reviewed. But in the process of CF, especially in Japan, scientists appeal to the society through visual images but they are not peer-reviewed. The concept of "Journal community" that evaluates each paper for the journal is known in the field of Science, Technology and Society (STS), but they advocated a new concept "Budget-funding community", in which the community decides whether to place a budget and it is also important in conventional science. H. Yokoyama hosted science communication in an annual meeting for CF at the Kavli IPMU [(2) of 9 challenges].

The radiosonde group led by Kavli IPMU affiliate member M. Minowa started an observational study to launch a radiosonde balloon with charged particle counters on it into thunderclouds. They search for high flux of relativistic electrons running downward in the thunderclouds. The electric field in the thunderclouds may accelerate cosmic ray electrons. By generating knock-on electrons successively, the accelerated electrons can cause an avalanche multiplication process called relativistic runaway electron avalanche (RREA). They may discover the existence of an electrostatic electron accelerator in the thunderclouds for the first time and identify the origin of the long burst thundercloud gamma rays observed on the ground and on high mountains. They have already carried out a radiosonde test flight successfully using this device from the rooftop of the Kavli IPMU building.

We held the 1st Kavli IPMU Artist in Residence (AIR) Program Artist Exhibition "reⁿ-Encounter between Science and Art 2018". A. Tsuboi at the Kavli IPMU hosted the exhibition with support from JSPS grant-in-aid to aim for advancing fusion of art and science. Since 2015, the Kavli IPMU hosted the AIR program where artists stay in the institute for about a month, interact with scientists and work on their new work. K. Haruyama (sculptor), N. Hirakawa (media artist) and Y. Nomura (painter), whom we have welcomed in the AIR program, presented their new artworks in the Exhibition. [(2) of 9 challenges].

We hired C.-T. Hsieh as a joint postdoc with the Institute for Solid State Physics and conduct joint seminars occasionally.

We regularly host interdisciplinary seminars. In FY 2017, we held 74 mathematics-string (MS) theory seminars, and 94 astronomy-particle physics-experimental physics-cosmology (APEC) seminars in addition to 18 special seminars and 6 colloquia.

The Kavli IPMU and the Earth-Life Science Institute (ELSI) joint public lecture on 'A Question of Origins' was held at the Tokyo Institute of Technology's Kuramae Hall. It covered the origins of space, the Earth and life. Kavli IPMU PI, N. Sugiyama presented about the origin of the universe. The audience enjoyed the most advanced science and research in an easy-to-grasp conversation between scientists and philosophers.

The Kavli IPMU and the Institute for Cosmic Ray Research (ICRR) held a joint public lecture "Circus of waves and grains: A look at the tiny phenomena with big effects on the Universe".

3. Establishing international research environment

* Describe what's been accomplished in the efforts to raise the center's recognition as a genuine globally visible research institute, along with innovative efforts proactively being taken in accordance with the development stage of the center, including the following points, for example:

- Efforts being developed based on the analysis of number and state of world-leading, frontline researchers; number and state of visiting researchers; exchanges with overseas entities
- Proactive efforts to raise the level of the center's international recognition
- Efforts to make the center into one that attracts excellent young researchers from around the world (such as efforts fostering young researchers and contributing to advancing their career paths)

One clear example of evidence of establishing the institute as a highly reputed international research center during this decade was manifested at the Kavli IPMU 10th year anniversary symposium held in October. A total of about 200 researchers came together including on-site faculties, postdocs, students and also alumni in three-day meeting. About 40% of participants were foreigners including Nobel laureates and Field Medalists. Two Nobel laureates, Profs. T. Kajita and D. Gross, presented talks in physics. Two Fields medalists, Profs. A. Okounkov and S.-T. Yau presented talks in mathematics. Not only these world-leading presentations, also 20 poster presentations were shown by young faculty members and postdocs simultaneously covering prominent research fields in theoretical physics, experimental physics, astronomy and mathematics.

FY 2017 was the first year of the 5-year extension of the WPI support to achieve the proposed 9 challenges. To realize (5) of these challenges, we retained the best and broadly minded scientists from around the world. The total number of Principal Investigators (PIs) increased from 19 to 26 and the average age of PI became 7 years younger than FY 2016. Among them, the number of on-site PIs increased from 5 to 9. All of our 26 Principal Investigators (7 non-Japanese: 27%) are world-leading scientists. Among PIs, M. Kapranov is a distinguished mathematician and conducts research as a leader in higher category theory. H. Murayama received a Research Award from the Alexander von Humboldt Foundation in recognition of giving a significant impact on relevant academic fields. In addition, he was named as one of the 100 influencers in the world listed in the book *Genius: 100 Visions of the Future*. E. Komatsu and D. Spergel were awarded the 2018 Breakthrough Prize in Fundamental Physics for their prominent research in developing detailed maps of the early Universe. Y. Nomura, a professor of UC Berkeley, is well known in the field of particle physics and cosmology, was named a new American Physical Society Fellow on his excellent work pioneering contributions to a variety of areas of particle theory. M. Vagins has lead the EGADS project and the concept will be realized in the on-going SK-Gd project. M. Takada is the leader of the HSC project, and the fruitful scientific results have just come out in the latest issue of the *Publications of the Astronomical Society of Japan* including 40 new studies related to HSC observation. Other faculty members also play leading roles in each field and include PIs of big international projects such as Belle II, KamLAND-Zen, SuMIRe, and LiteBIRD.

M. Yamazaki in string theory, S. More in astrophysics, and J. Silverman in astrophysics were all granted tenure after rigorous evaluation processes. T. Melia, a particle physicist talented in using advanced mathematics, as well as K.-G. Lee, a pioneer in mapping Intergalactic medium using Lyman-alpha absorption in high-z galaxies, were recruited as tenure-track Assistant Professors [(5)

of 9 challenges].

A large fraction of our researchers are non-Japanese. Out of 274 member researchers including faculty, postdoc, affiliate members, and long-time visitors, 111 (41%) are non-Japanese. During FY 2017, we had 738 (938) visitors (the numbers in the parentheses take into account multiple visits). Among them, 436 (510) are international and many of them are world-class scientists. The Kavli IPMU has been keeping its activity as a key hub for exciting intellectual exchange.

The Kavli IPMU hosted 11 international conferences and workshops in a broad range of fields: mathematics, string theory, theoretical astronomy, cosmology, galaxies, the Hyper-Kamiokande project and the T2K experiment. Among 672 participants in total, 236 were from foreign institutions. Holding conferences in the Kavli IPMU is important to raise our visibility in the international community and to show our leading roles in different fields.

Kavli IPMU researchers are mandated to spend 1-3 months in overseas institutes. This provides great opportunities for collaborative works and raises the visibility of the Kavli IPMU achievements. They presented more than 76 invited talks at both overseas and domestic institutions and conferences.

The Kavli IPMU signed 20 cooperative research agreements or memoranda of understanding (MOU). The agreement, initiated in 2016, with the Department of Physics at the University of Oxford for the purpose of the Kavli IPMU Oxford D.Phil. Fellowships is working effectively. In 2017, three new research agreements were signed with, the Kavli Institute for Astronomy and Astrophysics at Peking University (KIAA), le Centre National de la Recherche Scientifique (CNRS), and the Mainz Institute for Theoretical Physics (MITP).

Oxford doctoral students studying for D.Phil. research degrees in Astrophysics or Particle Physics at U Oxford are being supervised by faculty members of the Kavli IPMU and are being provided the opportunity to conduct research in collaboration with Kavli IPMU researchers [(7) of 9 challenges]. Also, the Kavli IPMU is working very well together with another international graduate program in physics (GSGC), which we hope will be extended to astronomy. Young students are becoming attracted to the Kavli IPMU.

We recruit the brightest young people from around the world as postdoctoral researchers and provide them with the best research environment so that they can conduct outstanding research. In the winter of 2017, the Kavli IPMU received 657 applications in total for the postdoctoral positions including Kavli fellows and newly established KIAA-Kavli IPMU fellows and nearly 90% of these applications are from outside Japan. In total, 20 new postdocs will arrive in FY 2018. Affiliation with the Kavli IPMU is now a successful career path. Out of 11 postdocs who left the Kavli IPMU in FY 2017, 4 assumed faculty positions, and 4 moved to other postdoctoral positions in universities or research institutes including Arizona University, Sun-Yat Sen University, Kyushu University, ICRR, Chulalong University, DESY, and RIKEN.

To further raise the Kavli IPMU's profile as a globally visible institute, online science news service such as EurekAlert!, AlphaGalileo and ResearchSEA have been used effectively to publicize our research activities to the world. It was initiated in 2014 and a number of international media coverages jumped from about 20 in 2013 to 200. Its number has kept at this level since then, and reached 222 in 2017.

4. Reforming the research organization

* If innovated system reforms generated by the center have had a ripple effect on other departments of the host institutions or on other research institutions, clearly describe in what ways.

* Please describe the center's operation and the host institution's commitment to the system reforms.

Kavli IPMU administrative staff members were awarded the U Tokyo's 2017 Special Prize for Business Transformation from the President for the fifth time, following 2008, 2013, 2015 and 2016. The Kavli IPMU team developed an education video in English to prevent harassment together with the University Harassment Counseling Center. A ripple effect of these system reforms has already spread widely within the University.

2008's achievement for "web site to accept the foreign researchers in Kashiwa Campus" has already been requested to be adopted by administrative sections of many other faculties. 2013's "thoroughgoing safety education by network distribution of education video and final quiz" has been requested to be adopted by the U Tokyo environmental and safety research center in Kashiwa, Graduate school of Engineering U Tokyo, Graduate school of Mathematical Science U Tokyo and ICRR. 2015's "language website to explain U Tokyo's employee procedures for international researchers" has been used freely through the U Tokyo website. 2016's "Win-Win project towards University Globalization" has been requested by the U Tokyo hospital medical administrative section and ICRR [(6) of 9 challenges].

The Kavli IPMU has already achieved many reforms, including non-traditional tenure positions, merit-based salary system, "nenpo" system for permanent faculty members, Kavli endowment and naming. Our successful system reforms have now spread over the rest of the University and are expected to produce ripple effects to other research institutions to help boost the overall competitiveness of Japan on a global scale. One of the successful ripple effects through the host institute has been cross-appointments. The number of cross-appointments in U Tokyo has become more than 70. It was initiated at the Kavli IPMU and has now spread over not only within U Tokyo, but also to other research institutions.

Regarding 'taking out walls between departments', Prof. H. Yokoyama, specialized in Science Communication and Policy, acts as a catalyst between the Kavli IPMU and the Interfaculty Initiative in Information Studies by accepting their PhD students. The LiteBIRD team started to collaborate with a group at the Graduate School of Frontier of Science U Tokyo, and also with a group at the Institute for Photon Science and Technology U Tokyo led by President M. Gonokami. We provide information to the newly established WPI institute, International Research Center for Neurointelligence (IRCN), in U Tokyo based on our 10 years of experiences.

5. Efforts to secure the center's future development over the mid- to long-term

* Please address the following items, which are essential to mid- to long-term center development:

- Future Prospects with regard to the research plan, research organization and PI composition; prospects for the fostering and securing of next-generation researchers
- Prospects for securing resources such as permanent positions and revenues; plan and/or implementation for defining the center's role and/or positioning the center within the host institution's institutional structure
- Measures to sustain the center as a world premier international research center after program funding ends
- Host institution's organizational reforms carried out for the Center's autonomous administration simultaneously with the creation of the Center.

The positioning of the Kavli IPMU within U Tokyo is quite clear. President Gonokami's 'Vision 2020' emphasizes the importance of "Expansion and Establishment of Internationally-renowned Bases for Research". An action to realize this vision 'Action 2020' has been set up saying "Establish and expand upon internationally-renowned bases for research at U Tokyo by carrying out such initiatives as advancing the development of both the University's strongest fields in which it is leading the world and unique areas of original research which should unwaveringly continue to be studied, promoting joint research and international collaboration that goes beyond the framework of U Tokyo, and creating new, interdisciplinary knowledge that is the first of its kind in the world." As already been declared by the President at the WPI Program Committee meeting in recent years, the President recognizes that the Kavli IPMU perfectly matches his vision as a role model for the rest of the University. The Kavli IPMU enhances the value of the University, which enables the University to attract new revenues. It is reasonable for U Tokyo to support the Kavli IPMU with top priority. We made the effort to strengthen the University's financial base.

Based on this stance, U Tokyo put together a plan for the extension period and beyond. U Tokyo has already provided 10 tenured positions, and permanent assignment of 9 administrative staff members. Thanks to MEXT, from FY 2018, the 'university functionality boost' budget from MEXT for 13 positions and for operation has been approved to be a permanent budget. The University will maintain and hopefully expand the Kavli IPMU even after WPI support finishes.

A new budget request in the period from FY 2018 to FY 2021 was ranked as No.1 in U Tokyo, while it was not approved by the government. This budget request is crucial to sustain the Kavli IPMU

permanently, and we will keep making the request continuously [(9) of 9 challenges].

Main scientific projects are going on well thanks to our PIs, faculty members and postdocs. HSC, one of the main projects in the Kavli IPMU, led by M. Takada has performed an analysis based on the first two years data and has made advances in research in many areas of astronomy and physics. Construction of PFS, the powerful tool for spectroscopy, will be completed in two years. The Kavli IPMU has been the key institute of this international collaborative project. Gadolinium-doped Super-Kamiokande (SK) project, SK-Gd, is now in the construction phase at Kamioka, and is expected to collect some new supernova neutrinos in about three years. Dark matter search project XMASS will join XENONnT project at Gran Sasso in Italy. Accumulated experimental expertise of XMASS will contribute to handling of xenon with radio-purification, and neutron veto. LiteBIRD is one of the projects on the MEXT Roadmap in Japan and the master plan of Science Council. Kavli IPMU team is the main proponent, involved in developing cryogenic detectors and relevant equipment to verify the technical feasibility of LiteBIRD.

Regarding neutrino experiments, the Kavli IPMU is a part of the new 'Next-generation Neutrino Science Organization' together with ICRR and the Faculty of Science to advance future experiments for neutrino research. This organization is based on the newly defined category for interdisciplinary research in U Tokyo. To realize Kavli IPMU's beneficial activity to the society, Gamma-ray imaging project for medical research has just started. This research brings advanced technologies of space instruments to bio-medical and drug research, and gives an impact on innovation of cancer research targeting within about three years. Collaboration and stimulation among fields of mathematics and theoretical physics will be strengthened in coming years.

The total number of Principal Investigators increased from 19 to 26, making the average age become younger by 7 years compared to that of FY 2016. All of our 26 Principal Investigators (7 non-Japanese: 27%) are world-leading scientists. A gamma-ray imaging researcher is expected to be assigned as a new PI early in FY 2018.

6. Others

* In addition to the above 1-5 evaluation items, only if there is anything else that deserves mention regarding the center project's progress, please note it.

Two new female faculty professors were recruited successfully. Prof. H. Yokoyama is specialized in Science Communication and Policy. She can provide advice for outreach to high school teachers. Prof. Y. Ito, currently a cross-appointment with Nagoya University, is a mathematician in Algebraic Geometry working on McKay correspondence using inspiration from physics.

Our PI, Y.-K. Kim was elected to the American Academy of Arts and Science as a member of its 237th class. She is the fourth researcher from the Kavli IPMU to become a member. Also she gave a talk at the Kavli IPMU Science Café titled 'What Can A Particle Accelerator Discover?'

H. Ooguri was elected to the Japan Writers' Association. He was nominated to the Association by the Vice Chair Masahiro Mita and the Board member Masahiko Murakami. He published a new book titled as 'Quest to the Truth – Dialogue between Buddhism and Astrophysics'.

Hamamatsu Photonics K.K. was awarded the U Tokyo, Shokumon Award in recognition of establishing the first endowed professorship for fundamental science and their support for Kavli IPMU research into the Dark side of the universe.

The Kavli IPMU, the Institute for Solid State Physics, and the Institute for Cosmic Ray Research jointly hosted an event called "Actually I Really Love Physics!—Career Paths of Female Physics Graduates" at the Kavli IPMU for the second time, and there were 19 participants. This event was held to support female students in physics to plan their careers.

The Kavli IPMU and Tamarokuto Science Center co-hosted a series of Science Cafes. A Kavli IPMU project researcher, W. Donovan, presented his works on mathematics by linking between soap bubbles and spacetime. Another Kavli IPMU project researcher, D. Stark, presented his works on the

birth, growth, and death of galaxies.

H. Murayama and H. Yokoyama started the proposed activity to enlarge the force for outreach to young students, by organizing workshops for scientists and high school teachers along with the Consortium for Renovating Education of the Future, U Tokyo (CoREF). [(8) of 9 challenges]

7. Center's response to the follow up results in last year

* Transcribe the item from the "Advice/ recommendations" section in the site visit report and "Actions required and recommendations" in the Follow-up report, then note how the center has responded to them.

* For the center launched in FY 2017, please describe the status of response to the pointed items in "Major points that need to be improved" of "The screening result for WPI centers launched in FY 2017."

* However, if you have already provided this information, please indicate where in the report.

[FY 2017 WPI Site Visit Report for FY 2016 activity Kavli IPMU on 19 July 2017]

"8. Advice/recommendations"

- One of the purposes of WPI is to revolutionize the way research is conducted in Japan. One specific suggestion is to take down walls between departments.
- It is very encouraging to see that this is being realized at smaller universities. For an institution as large as U Tokyo, it is possible to avoid this reform, and still sustain the center's development even after the WPI support runs out.
- To accomplish this, U Tokyo requests MEXT to increase the total funding.
- U Tokyo may want to modernize research areas. To perform a reform at this level, U Tokyo should begin to slowly take out walls between departments.

(regarding 'taking out walls between departments')

- We have established the 'Next-generation Neutrino Science Organization' together with ICRR and the Faculty of Science, based on a newly defined category for interdisciplinary research in U Tokyo.
- We work with the Faculty of Science through an acceptance procedure for Oxford students and new graduate programs GSGC.
- Most departments are members of the University Budget Committee, and they recognize the Kavli IPMU as a role model for research institutes. This recognition will help lowering the departmental barriers.
- Prof. H. Yokoyama, conducting research in Science Communication and Policy, acts as a catalyst between the Kavli IPMU and the Interfaculty Initiative in Information Studies by accepting PhD students.
- We hired a joint postdoc with the Institute for Solid State Physics and conduct joint seminars occasionally.
- We have been in a close contact to IRCN, the new WPI institute in U Tokyo, for sharing our 10-year experience with WPI.

(regarding to 'budget request to MEXT')

- U Tokyo budget committee ranked Kavli IPMU budget request to MEXT as No.1 among all budget request proposals from U Tokyo.
- U Tokyo put the Kavli IPMU as the top priority institute for support.
- MEXT budget 'university functionality boost' was reassigned as a permanent operating budget. This is a great step toward a self-sustaining institute.
- Based on our request, U Tokyo keeps making budget request to MEXT to sustain the Kavli IPMU as a permanent institute at the current size before the extension will over.

[Follow up on the Kavli IPMU, Launched in 2007]

"Actions required and recommendations"

Nothing was pointed out.

Appendix 1 FY2017 List of Center's Research Results and Main Awards

1. Refereed Papers

- List only the Center's papers published in 2017. (Note: The list should be for the calendar year, not the fiscal year.)

(1) Divide the papers into two categories, A and B.

A. WPI papers

List papers whose author(s) can be identified as affiliated with the WPI program (e.g., that state the name of his/her WPI center). (Not including papers in which the names of persons affiliated with the WPI program are contained only in acknowledgements.)

B. WPI-related papers

List papers related to the WPI program but whose authors are not noted in the institutional affiliations as WPI affiliated. (Including papers whose acknowledgements contain the names of researchers affiliated with the WPI program.)

Note: On 14 December 2011, the Basic Research Promotion Division in MEXT's Research Promotion Bureau circulated an instruction requiring paper authors to include the name or abbreviation of their WPI center among their institutional affiliations. As some WPI-affiliated authors of papers published up to 2011 may not be aware of this requirement, their papers are treated as "WPI-related papers." From 2012, however, the authors' affiliations must be clearly noted and only category A papers will be basically listed.

(2) Method of listing paper

- List only referred papers. Divide them into categories (e.g., original articles, reviews, proceedings).

- For each, write the author name(s); year of publication; journal name, volume, page(s), and article title. Any listing order may be used as long as format is the same. (The names of the center researchers do not need to be underlined.)

- If a paper has many authors (say, more than 20), all of their names do not need to be listed.

- If the papers are written in languages other than English, divide them into paper's categories when listing them.

- Assign a serial number to each paper to be used to identify it throughout the system.

- Order of Listing

A. WPI papers

1. Original articles

2. Review articles

3. Proceedings

4. Other English articles

5. Articles written in other than English

B. WPI-related papers

1. Original articles

2. Review articles

3. Proceedings

4. Other English articles

5. Articles written in other than English

(3) Submission of electronic data

- In addition to the above, provide a .csv file output from the Web of Science (e.g.) or other database giving the paper's raw data including Document ID. (Note: the Document ID is assigned by paper database.)

- These files do not need to be divided into paper categories.

(4) Use in assessments

- The lists of papers will be used in assessing the state of WPI project's progress in FY 2017.

- They will be used as reference in analyzing the trends and whole states of research in the said WPI center, not to evaluate individual researcher performance.

- The special characteristics of each research domain will be considered when conducting assessments.

(5) Additional documents

- After all documents, including these paper listings, showing the state of research progress have been submitted, additional documents may be requested.

A. WPI papers

1. Original articles

| No. | Author names and details |
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| 1 | On the Large R-charge Expansion in N=2 Superconformal Field Theories Hellerman, S; Maeda, S JOURNAL OF HIGH ENERGY PHYSICS (12), 135, DEC 27, 2017 |
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N/A

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N/A

B. WPI-related papers

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| 313 | Predicting emission line fluxes and number counts of distant galaxies for cosmological surveys Valentino, F; Daddi, E; Silverman, JD; Puglisi, A; Kashino, D; Renzini, A; Cimatti, A; Pozzetti, L; Rodighiero, G; Pannella, M; Gobat, R; Zamorani, G MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 472(4), pp.4878-4899, DEC, 2017 |
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| 315 | 8d gauge anomalies and the topological Green-Schwarz mechanism Garcia-Etxebarria, I; Hayashi, H; Ohmori, K; Tachikawa, Y; Yonekura, K JOURNAL OF HIGH ENERGY PHYSICS (11), 177, NOV 27, 2017 |
| 316 | SCALA: In situ calibration for integral field spectrographs Lombardo, S et al. ASTRONOMY & ASTROPHYSICS 607, A113, NOV 23, 2017 |
| 317 | SCUBA-2 Ultra Deep Imaging EAO Survey (STUDIES): Faint-end Counts at 450 μm Wang, WH et al. ASTROPHYSICAL JOURNAL 850(1), 37, NOV 20, 2017 |
| 318 | Liouville action as path-integral complexity: from continuous tensor networks to AdS/CFT Caputa, P; Kundu, N; Miyaji, M; Takayanagi, T; Watanabe, K JOURNAL OF HIGH ENERGY PHYSICS (11), 97, NOV 16, 2017 |
| 319 | Prediction of the CP asymmetry $C-00$ in $B-0 \rightarrow D-0 \langle \overline{D-0} \rangle$ deca Sahoo, D; Cheng, HY; Chiang, CW; Kim, CS; Sinha, R JOURNAL OF HIGH ENERGY PHYSICS (11), 87, NOV 15, 2017 |
| 320 | Predictions for the neutrino parameters in the minimal gauged $U(1)(L \mu-L \tau)$ model Asai, K; Hamaguchi, K; Nagata, N EUROPEAN PHYSICAL JOURNAL C 77(11), 763, NOV 14, 2017 |
| 321 | Radiative corrections to Higgs couplings with weak gauge bosons in custodial multi-Higgs models Chiang, CW; Kuo, AL; Yagyu, K PHYSICS LETTERS B 774, pp.119-122, NOV 10, 2017 |
| 322 | On gauge dependence of gravitational waves from a first-order phase transition in classical scale-invariant $U(1)'$ models Chiang, CW; Senaha, E PHYSICS LETTERS B 774, pp.489-493, NOV 10, 2017 |
| 324 | Revisiting arithmetic solutions to the $W=0$ condition Kanno, K; Watari, T PHYSICAL REVIEW D 96(10), 106001, NOV 2, 2017 |
| 325 | Multidimensional Vlasov-Poisson Simulations with High-order Monotonicity- and Positivity-preserving Schemes Tanaka, S; Yoshikawa, K; Minoshima, T; Yoshida, N ASTROPHYSICAL JOURNAL 849(1), 76, NOV 1, 2017 |

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| 326 | Energy Spectrum of Cosmic-Ray Electron and Positron from 10 GeV to 3 TeV Observed with the Calorimetric Electron Telescope on the International Space Station Adriani, O et al. PHYSICAL REVIEW LETTERS 119(18), 181101, NOV 1, 2017 |
| 327 | The impact of chemistry on the structure of high-z galaxies Pallottini, A; Ferrara, A; Bovino, S; Vallini, L; Gallerani, S; Maiolino, R; Salvadori, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 471(4), pp.4128-4143, NOV, 2017 |
| 328 | Molecular clumps photoevaporation in ionized regions Decataldo, D; Ferrara, A; Pallottini, A; Gallerani, S; Vallini, L MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 471(4), pp.4476-4487, NOV, 2017 |
| 329 | CFT descriptions of bulk local states in the AdS black holes Goto, K; Takayanagi, T JOURNAL OF HIGH ENERGY PHYSICS (10), 153, OCT 23, 2017 |
| 330 | Galaxies into the Dark Ages Carilli, CL; Murphy, EJ; Ferrara, A; Dayal, P ASTROPHYSICAL JOURNAL 848(1), 49, OCT 10, 2017 |
| 331 | Small instanton transitions for M5 fractions Mekareeya, N; Ohmori, K; Shimizu, H; Tomasiello, A JOURNAL OF HIGH ENERGY PHYSICS (10), 55, OCT 10, 2017 |
| 332 | Symmetry breaking operators for the restriction of representations of indefinite orthogonal groups $O(p, q)$ Kobayashi, T; Leontiev, A PROCEEDINGS OF THE JAPAN ACADEMY SERIES A-MATHEMATICAL SCIENCES 93(8), pp.86-91, OCT, 2017 |
| 333 | Supersonic gas streams enhance the formation of massive black holes in the early universe Hirano, S; Hosokawa, T; Yoshida, N; Kuiper, R SCIENCE 357(6358), pp.1375-1377, SEP 29, 2017 |
| 334 | E-8 instantons on type-A ALE spaces and supersymmetric field theories Mekareeya, N; Ohmori, K; Tachikawa, Y; Zafrir, G JOURNAL OF HIGH ENERGY PHYSICS (9), 144, SEP 28, 2017 |
| 335 | Distinguishability of black hole microstates Bao, N; Ooguri, H PHYSICAL REVIEW D 96(6), 66017, SEP 18, 2017 |
| 336 | Derivation of the Time-Reversal Anomaly for (2+1)-Dimensional Topological Phases Tachikawa, Y; Yonekura, K PHYSICAL REVIEW LETTERS 119(11), 111603, SEP 13, 2017 |
| 337 | Smallest 3d hyperbolic manifolds via simple 3d theories Gang, DM; Tachikawa, Y; Yonekura, K PHYSICAL REVIEW D 96(6), 61701, SEP 12, 2017 |
| 338 | Gravitino/axino as decaying dark matter and cosmological tensions Hamaguchi, K; Nakayama, K; Tang, Y PHYSICS LETTERS B 772, pp.415-419, SEP 10, 2017 |
| 339 | On hydrogen-like bound states in $N=4$ super Yang-Mills Sakata, Y; Schneider, R; Tachikawa, Y; Yamaura, T JOURNAL OF HIGH ENERGY PHYSICS (9), 15, SEP 5, 2017 |

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| 340 | Out-of-time-ordered correlators in a $(T-2)(n) / Z(n)$ CFT Caputa, P; Kusuki, Y; Takayanagi, T; Watanabe, K PHYSICAL REVIEW D 96(4), 46020, AUG 30, 2017 |
| 341 | Galaxy Formation through Filamentary Accretion at $z=6.1$ Jones, GC; Willott, CJ; Carilli, CL; Ferrara, A; Wang, R; Wagg, J ASTROPHYSICAL JOURNAL 845(2), 175, AUG 20, 2017 |
| 342 | Anti-de Sitter Space from Optimization of Path Integrals in Conformal Field Theories Caputa, P; Kundu, N; Miyaji, M; Takayanagi, T; Watanabe, K PHYSICAL REVIEW LETTERS 119(7), 71602, AUG 18, 2017 |
| 343 | No inflation in type IIA strings on rigid Calabi-Yau spaces Wakimoto, Y; Ketov, SV PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (8), 8300,, AUG, 2017 |
| 344 | The inner structure of early-type galaxies in the Illustris simulation Xu, DD; Springel, V; Sluse, D; Schneider, P; Sonnenfeld, A; Nelson, D; Vogelsberger, M; Hernquist, L MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 469(2), pp.1824-1848, AUG, 2017 |
| 345 | Modelling the Type Ic SN 2004aw: a moderately energetic explosion of a massive C plus O star without a GRB Mazzali, PA; Sauer, DN; Pian, E; Deng, J; Prentice, S; Ben Ami, S; Taubenberger, S; Nomoto, K MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 469(2), pp.2498-2508, AUG, 2017 |
| 346 | New Kaluza-Klein instantons and the decay of AdS vacua Ooguri, H; Spodyneiko, L PHYSICAL REVIEW D 96(2), 26016, JUL 19, 2017 |
| 347 | From 4d Yang-Mills to 2d CPN-1 model: IR problem and confinement at weak coupling Yamazaki, M; Yonekura, K JOURNAL OF HIGH ENERGY PHYSICS (7), 88, JUL 18, 2017 |
| 348 | Dirac CP phase in the neutrino mixing matrix and the Froggatt-Nielsen mechanism with $\det[M-\nu]=0$ Kaneta, Y; Tanimoto, M; Yanagida, TT PHYSICS LETTERS B 770, pp.546-550, JUL 10, 2017 |
| 349 | Beijing Lectures on the Grade Restriction Rule Eager, R; Hori, K; Knapp, J; Romo, M CHINESE ANNALS OF MATHEMATICS SERIES B 38(4), pp.901-912, JUL, 2017 |
| 350 | Sloan Digital Sky Survey IV: Mapping the Milky Way, Nearby Galaxies, and the Distant Universe Blanton, MR et al. ASTRONOMICAL JOURNAL 154(1), 28, JUL, 2017 |
| 351 | ALMA observations of cold molecular gas in AGN hosts at $z \sim 1.5$ -evidence of AGN feedback? Kakkad, D; Mainieri, V; Brusa, M; Padovani, P; Carniani, S; Feruglio, C; Sargent, M; Husemann, B; Bongiorno, A; Bonzini, M; Piconcelli, E; Silverman, JD; Rujopakarn, W MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 468(4), pp.4205-4215, JUL, 2017 |
| 352 | Impact of axisymmetric mass models for dwarf spheroidal galaxies on indirect dark matter searches Klop, N; Zandanel, F; Hayashi, K; Ando, S PHYSICAL REVIEW D 95(12), 123012, JUN 22, 2017 |

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| 353 | Evolution of entanglement entropy in orbifold CFTs Caputa, P; Kusuki, Y; Takayanagi, T; Watanabe, K JOURNAL OF PHYSICS A-MATHEMATICAL AND THEORETICAL 50(24), 244001, JUN 16, 2017 |
| 354 | Probing minimal SUSY scenarios in the light of muon g-2 and dark matter Endo, M; Hamaguchi, K; Iwamoto, S; Yanagi, K JOURNAL OF HIGH ENERGY PHYSICS (6), 31, JUN 6, 2017 |
| 355 | 4d N=1 from 6d N = (1,0) on a torus with fluxes Bah, I; Hanany, A; Maruyoshi, K; Razamat, SS; Tachikawa, Y; Zafrir, G JOURNAL OF HIGH ENERGY PHYSICS (6), 22, JUN 5, 2017 |
| 356 | Holographic entanglement entropy on generic time slice Kusuki, Y; Takayanagi, T; Umemoto, K JOURNAL OF HIGH ENERGY PHYSICS (6), 21, JUN 5, 2017 |
| 357 | GENERALIZED DONALDSON-THOMAS INVARIANTS ON THE LOCAL PROJECTIVE PLANE Toda, Y JOURNAL OF DIFFERENTIAL GEOMETRY 106(2), pp.341-369, JUN, 2017 |
| 358 | Non-commutative thickening of moduli spaces of stable sheaves Toda, Y COMPOSITIO MATHEMATICA 153(6), pp.1153-1195, JUN, 2017 |
| 359 | The Complete Calibration of the Color-Redshift Relation (C3R2) Survey: Survey Overview and Data Release 1 Masters, DC; Stern, DK; Cohen, JG; Capak, PL; Rhodes, JD; Castander, FJ; Paltani, S ASTROPHYSICAL JOURNAL 841(2), 111, JUN 1, 2017 |
| 360 | The Horizon-AGN simulation: evolution of galaxy properties over cosmic time Kaviraj, S; Laigle, C; Kimm, T; Devriendt, JEG; Dubois, Y; Pichon, C; Slyz, A; Chisari, E; Peirani, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 467(4), pp.4739-4752, JUN, 2017 |
| 361 | Inflation from (R plus gamma R-n-2 Lambda) gravity in higher dimensions Ketov, SV; Nakada, H PHYSICAL REVIEW D 95(10), 103507, MAY 15, 2017 |
| 362 | Energy calibration of CALET onboard the International Space Station Asaoka, Y et al. ASTROPARTICLE PHYSICS 91, pp.1-10, MAY, 2017 |
| 363 | Optical and ultraviolet spectroscopic analysis of SN 2011fe at late times Friesen, B; Baron, E; Parrent, JT; Thomas, RC; Branch, D; Nugent, PE; Hauschildt, PH; Foley, RJ; Wright, DE; Pan, YC; Filippenko, AV; Clubb, KI; Silverman, JM; Maeda, K; Shivvers, I; Kelly, PL; Cohen, DP; Rest, A; Kasen, D MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 467(2), pp.2392-2411, MAY, 2017 |
| 364 | Boundary operators in effective string theory Hellerman, S; Swanson, I JOURNAL OF HIGH ENERGY PHYSICS (4), 85, APR 13, 2017 |
| 365 | Higgs mechanism and cosmological constant in N=1 supergravity with inflaton in a vector multiplet Aldabergenov, Y; Ketov, SV EUROPEAN PHYSICAL JOURNAL C 77(4), 233, APR 12, 2017 |

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| 367 | The redshift-selected sample of long gamma-ray burst host galaxies: The overall metallicity distribution at $z < 0.4$ Niino, Y; Aoki, K; Hashimoto, T; Hattori, T; Ishikawa, S; Kashikawa, N; Kosugi, G; Onoue, M; Toshikawa, J; Yabe, K PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 69(2), 27, APR, 2017 |
| 368 | Cosmological constraints on scalar-tensor gravity and the variation of the gravitational constant Ooba, J; Ichiki, K; Chiba, T; Sugiyama, N PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (4), 43000,, APR, 2017 |
| 369 | The clustering of galaxies in the completed SDSS-III Baryon Oscillation Spectroscopic Survey: tomographic BAO analysis of DR12 combined sample in Fourier space Zhao, GB et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 466(1), pp.762-779, APR, 2017 |
| 370 | From path integrals to tensor networks for the AdS/CFT correspondence Miyaji, M; Takayanagi, T; Watanabe, K PHYSICAL REVIEW D 95(6), 66004, MAR 6, 2017 |
| 371 | Energy conditions in Starobinsky supergravity Addazi, A; Ketov, SV JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (3), 61, MAR, 2017 |
| 372 | The SEEDS High-Contrast Imaging Survey of Exoplanets Around Young Stellar Objects Uyama, T et al. ASTRONOMICAL JOURNAL 153(3), 106, MAR, 2017 |
| 373 | On time-reversal anomaly of 2+1d topological phases Tachikawa, Y; Yonekura, K PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (3), 033B04, MAR, 2017 |
| 374 | Zooming on the internal structure of z similar or equal to 6 galaxies Pallottini, A; Ferrara, A; Gallerani, S; Vallini, L; Maiolino, R; Salvadori, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 465(3), pp.2540-2558, MAR, 2017 |
| 375 | SDSS-IV MaNGA: environmental dependence of stellar age and metallicity gradients in nearby galaxies Zheng, Z et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 465(4), pp.4572-4588, MAR, 2017 |
| 376 | The Extinction Properties of and Distance to the Highly Reddened Type IA Supernova 2012cu Huang, X et al. ASTROPHYSICAL JOURNAL 836(2), 157, FEB 20, 2017 |
| 377 | Inferring physical properties of galaxies from their emission-line spectra Ucci, G; Ferrara, A; Gallerani, S; Pallottini, A MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 465(1), pp.1144-1156, FEB 11, 2017 |
| 378 | Dark matter in axion landscape Daido, R; Kobayashi, T; Takahashi, F PHYSICS LETTERS B 765, pp.293-299, FEB 10, 2017 |
| 379 | Black hole singularity, generalized (holographic) c-theorem and entanglement negativity Banerjee, S; Paul, P JOURNAL OF HIGH ENERGY PHYSICS (2), 43, FEB 8, 2017 |

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| 380 | Affleck-Dine leptogenesis with varying Peccei-Quinn scale Bae, KJ; Baer, H; Hamaguchi, K; Nakayama, K JOURNAL OF HIGH ENERGY PHYSICS (2), 17, FEB 3, 2017 |
| 381 | Modular Categories, Crossed S-matrices, and Shintani Descent Deshpande, T INTERNATIONAL MATHEMATICS RESEARCH NOTICES (4), pp.967-999, FEB, 2017 |
| 382 | Photometric properties of intermediate-redshift Type Ia supernovae observed by the Sloan Digital Sky Survey-II Supernova Survey Takanashi, N; Doi, M; Yasuda, N; Kuncarayakti, H; Konishi, K; Schneider, DP; Cinabro, D; Marriner, J MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 465(2), pp.1274-1288, FEB, 2017 |
| 383 | Flaxion: a minimal extension to solve puzzles in the standard model Ema, Y; Hamaguchi, K; Moroi, T; Nakayama, K JOURNAL OF HIGH ENERGY PHYSICS (1), 96, JAN 23, 2017 |
| 384 | SCEXAO AND GPI Y JH BAND PHOTOMETRY AND INTEGRAL FIELD SPECTROSCOPY OF THE YOUNG BROWN DWARF COMPANION TO HD 1160 Garcia, EV et al. ASTROPHYSICAL JOURNAL 834(2), 162, JAN 10, 2017 |
| 385 | CP violating phase from minimal texture neutrino mass matrix: Test of the phase relevant to leptogenesis Fukugita, M; Kaneta, Y; Shimizu, Y; Tanimoto, M; Yanagida, TT PHYSICS LETTERS B 764, pp.163-166, JAN 10, 2017 |
| 386 | Surjectivity of a gluing construction in special Lagrangian geometry Imagi, Y COMMUNICATIONS IN ANALYSIS AND GEOMETRY 25(5), pp.1019-1061, , 2017 |
| 387 | The double-soft limit in cosmological correlation functions and graviton exchange effects Alinea, AL; Kubota, T; Misumi, N JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (1), 34, JAN, 2017 |
| 388 | Time-dependent ionization in the envelopes of type II supernovae at the photospheric phase Potashov, MS; Blinnikov, SI; Utrobin, VP ASTRONOMY LETTERS-A JOURNAL OF ASTRONOMY AND SPACE ASTROPHYSICS 43(1), pp.36-49, JAN, 2017 |
| 389 | Testing galaxy formation models with galaxy stellar mass functions Lim, SH; Mo, HJ; Lan, TW; Menard, B MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 464(3), pp.3256-3270, JAN, 2017 |
| 390 | Radial decoupling of small and large dust grains in the transitional disk RX J1615.3-3255 Kooistra, R et al. ASTRONOMY & ASTROPHYSICS 597, A132, JAN, 2017 |
| 391 | The Hall algebra of a curve Kapranov, M; Schiffmann, O; Vasserot, E SELECTA MATHEMATICA-NEW SERIES 23(1), pp.117-177, JAN, 2017 |
| 392 | NEAR-INFRARED IMAGING POLARIMETRY OF INNER REGION OF GG TAU A DISK Yang, Y et al. ASTRONOMICAL JOURNAL 153(1), 7, JAN, 2017 |

2. Review articles

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| 323 | A brief review of the 2d/4d correspondences Tachikawa, Y JOURNAL OF PHYSICS A-MATHEMATICAL AND THEORETICAL 50(44), 443012, NOV 3, 2017 |
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3. Proceedings

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| 366 | Nonlinearity and pixel shifting effects in HXRG infrared detectors Plazas, A; Shapiro, C; Smith, R; Rhodes, J; Huff, E JOURNAL OF INSTRUMENTATION 12, C04009, APR, 2017 |
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4. Other English articles

N/A

5. Articles written in other than English

N/A

2. Invited Lectures, Plenary Addresses (etc.) at International Conferences and International Research Meetings

- List up to 10 main presentations during FY2017 in order from most recent.
- For each, write the lecturer/presenter's name, presentation title, conference name and date(s)

- 1) Masahiro Kawasaki, "Formation of primordial black holes in multi-field inflation models",
14th International Conference of Computational Method in Science and Engineering (ICCMSE 2018),
March 14-18, 2018
- 2) Ken'ichi Nomoto, "First Stars and First Supernovae", Transient Universe conference, February 28, 2018
- 3) Hitoshi Murayama, "Dark Matter and Fundamental Physics", Texas 2017,
the 29th International Texas Symposium on Relativistic Astrophysics, December 3-8, 2017
- 4) Mikhail Kapranov, "Fourier transform on hyperplane arrangements",
2017 U Chicago Math Conference-Interactions between Representation Theory and Algebraic Geometry,
August 21-25, 2017
- 5) Kentaro Hori, "Boundary conditions in 2d (2,2) gauge theories", String Math 2017, July 24-28, 2017
- 6) Yuji Tachikawa, "Time-reversal Anomalies of 2+1d Topological Phases", Strings 2017, June 26, 2017
- 7) Hiroshi Ooguri, "Swampland Constraints", PASCOS 2017, June 19-23, 2017
- 8) Toshiyuki Kobayashi, "Symmetry Breaking Operators in Conformal Geometry",
X. International Symposium QUANTUM THEORY AND SYMMETRIES, June 19, 2017
- 9) Shigeki Matsumoto, "Estimating J-factors of dSphs for indirect dark matter detection",
PLANCK 2017: 20th Planck Conference from Kazimierz to Warsaw, May 21, 2017
- 10) Hitoshi Murayama, the concluding "Theory vision" plenary talk at LHC Physics Conference, May 20, 2017

3. Major Awards

- List up to 10 main awards received during FY2017 in order from the most recent.
- For each, write the recipient's name, name of award, and year issued.
- In case of multiple recipients, underline those affiliated with the center.

- 1) Yasunori Nomura, American Physical Society Fellow, 2017
- 2) Daisuke Kaneko, The 12th Young Scientist Award of the Physical Society of Japan, 2017
- 3) David Spergel & Eiichiro Komatsu, 2018 Breakthrough Prize in Fundamental Physics, 2017
- 4) Takashi Shimizu, Hiroshi Ooguri, Miraikan (National Museum of Emerging Science and Innovation),
Best of IFF Award & Best 3D Show Award of Immersive film festival, 2017
- 5) Daisuke Kaneko, The 19th Incentive award of the Japan Association of High Energy Physics, 2017
- 6) J. Xavier Prochaska, Outstanding Faculty Award of UC Santa Cruz, 2017
- 7) Masaomi Tanaka, NCU-DELTA Young Astronomer Lectureship Award, 2107
- 8) Hitoshi Murayama, Humboldt Research Award, 2017
- 9) Yohei Ema, Kyohei Mukaida, Kazunori Nakayama and Takahiro Terada,
Particle Physics Medal: Young Scientist Award in Theoretical Particle Physics, 2017
- 10) Young-Kee Kim, Fellow of the American Academy of Arts and Sciences, 2017

Appendix 2 FY 2017 List of Principal Investigators

NOTE:

- Underline names of principal investigators who belong to an overseas research institution. Place an asterisk (*) by names of investigators considered to be ranked among world's top researchers.
- In case of researchers not listed in the latest report, attach "Biographical Sketch of a New Principal Investigator".

| | | <Results at the end of FY2017> | | | Principal Investigators Total: 26 | | |
|---|-----|---|---|-------------|---|--|--|
| Name | Age | Affiliation (Position title, department, organization) | Academic degree specialty | Effort (%)* | Starting date of project participation | Status of project participation (Describe in concrete terms) | Contributions by PIs from overseas research institutions |
| <u>Center director</u> <u>Hitoshi Murayama</u> | 54 | Director, Project Professor Kavli IPMU, UTIAS, The Univ. of Tokyo Professor Physics Dept., University of California, Berkeley | Ph.D. particle theory, cosmology | 85 | 10/1/2007 | Stays 70% at Kavli IPMU, and 30% at UC Berkeley of which a half of the time at Kavli IPMU Berkeley satellite. Joins videoconference 4 times a week. | Sending 2 young scientists (1 week each) and 2 PhD students (3 weeks each). Accepting 4 senior scientists (2 for 1 week and 2 for 2 weeks). |
| Hiroaki Aihara | 62 | Deputy Director Kavli IPMU, UTIAS, The Univ. of Tokyo Executive Director and Vice President The University of Tokyo | Ph.D. high energy physics | 30 | 10/1/2007 | Stays at Kavli IPMU once a month. Joins videoconference once a week. | |
| <u>Alexey Bondal</u> | 56 | Professor Steklov Mathematical Institute Project Professor Kavli IPMU, UTIAS, The Univ. of Tokyo | Ph.D. mathemati cs | 40 | 10/1/2007 | Stays at Kavli IPMU 6 months a year. Joins videoconference once a week for the rest of 6 months. | Accepting 1senior scientist (1week). |
| Kunio Inoue | 52 | Director, Professor RCNS, Tohoku University | Ph.D. astroparticl e physics | 45 | 10/1/2007 | Stays at Kamioka Branch once a week. | |
| Takaaki Kajita | 59 | Director, Professor ICRR, The University of Tokyo | Ph.D. astroparticl e physics | 10 | 10/1/2007 | Stays at Kamioka Branch once a month. Usually stays at ICRR which is right next to Kavli IPMU. | |
| <u>Stavros</u> <u>Katsanevas</u> | 64 | Professor, Université Paris Denis Diderot Director, laboratory of Astroparticle Physics and Cosmology (APC) Director, European Gravitational Observatory | Ph.D. astroparticl e physics | 10 | 10/1/2007 | Stays at Kavli IPMU once a year. Joins videoconference once a month. | Encouraging researches on neutrino physics and astroparticle physics. |

*Percentage of time that the principal investigator will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

| Name | Age | Affiliation (Position title, department, organization) | Academic degree specialty | Effort (%)* | Starting date of project participation | Status of project participation (Describe in concrete terms) | Contributions by PIs from overseas research institutions |
|------------------------|-----|--|---|-------------|---|---|---|
| Masahiro Kawasaki | 57 | Professor ICRR, The University of Tokyo | Ph.D. particle cosmology | 40 | 8/1/2015 | Stays at Kavli IPMU twice a week. | |
| Toshiyuki Kobayashi | 55 | Professor Graduate School of Mathematical Sciences, The Univ. of Tokyo | Ph.D. mathemati cs | 30 | 6/1/2011 | Stays at Kavli IPMU once a month. Joins videoconference once a month | |
| Toshitake Kohno | 62 | Professor Graduate School of Mathematical Sciences, The Univ. of Tokyo | Ph.D. mathemati cs | 40 | 10/1/2007 | Stays at Kavli IPMU once a week. Joins videoconference once a week. | |
| Masayuki Nakahata | 58 | Professor ICRR, The Univ. of Tokyo | Ph.D. astroparticl e physics | 40 | 10/1/2007 | Usually stays at Kamioka Branch. | |
| Mihoko Nojiri | 55 | Professor KEK | Ph.D. particle theory | 20 | 10/1/2007 | Stays at Kavli IPMU twice a week. | |
| <u>Hiroshi Ooguri</u> | 56 | Professor Physics Dept and Mathematics Dept, California Institute of Technology | Ph.D. string theory | 66 | 10/1/2007 | Stays at Kavli IPMU 3 months a year. Joins videoconference once a week for the rest of 9 months. | Accepting 1 young scientist (11days) and sending 1 young scientist (1week) |
| <u>David Spergel</u> | 57 | Professor Dept of Astrophysical Sciences, Princeton University | Ph.D. cosmology | 40 | 10/1/2007 | Stays at Kavli IPMU once a year. Joins videoconference once a week. | Gave a talk at the Kavli IPMU 10th anniversary symposium. |
| Naoshi Sugiyama | 56 | Professor Physics Dept., Nagoya University | Ph.D. cosmology | 30 | 10/1/2007 | Stays at Kavli IPMU once a month. Joins videoconference once a week. | |
| Kentaro Hori | 52 | Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. High Energy Physics, Theoretical Physics | 80 | 11/1/2008 | Stays at Kavli IPMU full time. | |
| Mikhail Kapranov | 55 | Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | PhD. Mathematic s | 100 | 5/16/2014 | Stays at Kavli IPMU full time. | |

*Percentage of time that the principal Investigator will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

| Name | Age | Position (Position title, department, organization) | Academic degree specialty | Effort (%)* | Starting date of project participation | Status of project participation (Describe in concrete terms) | Contributions by PIs from overseas research institutions |
|-------------------------|-----|--|---|-------------|---|--|--|
| <u>Young-Kee Kim</u> | 55 | Louis Block Distinguished Service Professor Dept of Physics, University of Chicago Principal Investigator Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. Physics | 10 | 4/1/2017 | Stays at Kavli IPMU once a year. Joins videoconference once a week. | Gave a talk at an event to Support Science Courses Selection by Girls in Junior and Senior High School. |
| <u>Eiichiro Komatsu</u> | 43 | Director Dept. of Physical Cosmology, Max Planck Institute for Astrophysics PI Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. | 20 | 2/1/2008 | Stays at Kavli IPMU once a year. Joins videoconference once a week. | Accepting 2 young researchers (one for 11 months and the another for 2 months) and sending 2 young researchers (one for 2 weeks and another for 1 month) |
| Kai Martens | 54 | Principal investigator, Associate Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. Experiment al Neutrino Physics, Dark Matter Direct Detection | 80 | 10/1/2008 | Usually stays at Kamioka Branch. | |
| Shigeki Matsumoto | 45 | Associate Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. Particle Physics (Phenomen ology) | 80 | 10/1/2010 | Stays at Kavli IPMU full time. | |
| Shigetaka Moriyama | 48 | Professor Kamioka Observatory, Institute for Cosmic Ray Research, the Univ. of Tokyo | Ph. D Experiment al physics (Astroparti cle physics) | 20 | 2/1/2008 | Usually stays at Kamioka Branch. | |

*Percentage of time that the principal Investigator will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

| Name | Age | Affiliation (Position title, department, | Academic degree | Effort (%)* | Starting date of project participation | Status of project participation (Describe in concrete terms) | Contributions by PIs from overseas research institutions |
|-----------------------|-----|---|--|-------------|---|---|---|
| Yasunori Nomura | 44 | Principal Investigator Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The University of Tokyo Director Berkeley Center for Theoretical Physics, Univ. of California, Berkeley Professor Dept. of Physics, Univ. of California, Berkeley Senior Faculty Scientist Physics Division, Lawrence Berkeley National Laboratory | Ph. D. Quantum Gravity, Cosmology, Particle Physics Theory | 15 | 1/1/2010 | Stays at Kavli IPMU twice a year and organizing workshops for graduate students and postdocs. Joins videoconference once a week. | Sending 2 PhD students (3 weeks each) |
| Masahiro Takada | 44 | Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. Astronomy | 80 | 3/1/2008 | Stays at Kavli IPMU full time. | |
| Yukinobu Toda | 38 | Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. Mathematic s | 80 | 1/1/2008 | Stays at Kavli IPMU full time. | |
| Mark Robert Vagins | 52 | Professor Kavli Institute for the Physics and Mathematics of the Universe, UTIAS, The Univ. of Tokyo | Ph.D. High Energy Physics | 80 | 5/16/2008 | Stays at Kavli IPMU full time. | |
| Naoki Yoshida | 44 | PI Kavli IPMU, UTIAS, The University of Tokyo Professor Department of Physics, The University of Tokyo Principal Investigator Japan Science and Technology Agency | Ph.D. Cosmology | 40 | 4/1/2012 | Stays at Kavli IPMU twice a week. | |

*Percentage of time that the principal Investigator will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Researchers unable to participate in project in FY 2017

| Name | Affiliation (Position title, department, organization) | Starting date of project participation | Reasons | Measures taken |
|--------------------|---|---|--|------------------------|
| Yoichiro Suzuki | Deputy Director, Project Professor Kavli IPMU, UTIAS The University of Tokyo | 10/1/2007 | To concentrate on management of the institute as one of Deputy Directors. | assigned a replacement |
| Ken'ichi Nomoto | Senior Scientist, Kavli IPMU, UTIAS The University of Tokyo | 10/1/2007 | Step down as PI because of the age limit for retirement regulated by the University of Tokyo. | assigned a replacement |
| Kyoji Saito | Visiting Senior Scientist, Kavli IPMU, UTIAS The University of Tokyo | 10/1/2007 | Step down as PI because of the age limit for retirement regulated by the University of Tokyo. | assigned a replacement |
| <u>Henry Sobel</u> | Professor Dept of Physics and Astronomy University of California Irvine | 10/1/2007 | To concentrate on development of young researchers. | assigned a replacement |
| Tsutomu Yanagida | Project Professor Kavli IPMU, UTIAS The University of Tokyo | 10/1/2007 | To concentrate on development of young researchers. | assigned a replacement |

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Kentaro Hori (52)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Professor, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo

Academic degree and specialty

Ph.D, High Energy Physics, Theoretical Physics

Effort 80 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2015-Present: Professor, Kavli IPMU, The University of Tokyo

2008-2015: Project Professor, Kavli IPMU, The University of Tokyo

2007-2009: Associate Professor, Dept. of Phys. and Dept. of Math., The University of Toronto

2002-2007: Assistant Professor, Dept. of Phys. and Dept. of Math., The University of Toronto

2002: Member, The Institute for Advanced Study, Princeton

1999-2002: Postdoctoral Fellow, Harvard University

1996-1999: Postdoctoral Fellow, UC Berkeley

1994: Doctor of Science, Phys. Dept., The University of Tokyo

1989: Bachelor of Science, Phys. Dept., The University of Tokyo

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Proposed Virasoro Conjecture in Gromov-Witten theory (1997, with T. Eguchi and C. Xiong);

Derived Mirror Symmetry as a duality in quantum field theory (2000, with C. Vafa);

Obtained the Grade Restriction Rule for D-brane transfer (2008, with M. Herbst and D. Page);

Proposed Duality in 2d (2,2) supersymmetric gauge theory (2011);

Obtained exact formula for the partition function of supersymmetric gauge theories on 2d hemisphere (2013 with M. Romo), 2d torus (2013 with F. Benini, R. Eager and Y. Tachikawa) and circle (2014 with H. Kim and P. Yi).

Achievements

(1) International influence * Describe the kind of attributes listed below.

a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited speaker at the International Congress of Mathematicians 2002;

Plenary speaker at Strings 1998, Strings 2001, Strings 2003, String-Math 2011, String-Math 2014, Strings 2015, String-Math 2017;

Plenary Lectures in Summer Institute of Algebraic Geometry 2005 (once in ten years event).

b) Member of a scholarly academy in a major country

c) Recipient of international awards

d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

(3) Article citations (Titles of major publications, number of citations)

"Mirror Symmetry" (article), with C. Vafa, hep-th/0002222 (2000), cited 674 times;

"Mirror Symmetry" (book), with S. Katz, A. Klemm, R. Pandharipande, R. Thomas, C. Vafa, R. Vakil, E. Zaslow, Amer. Math. Soc./Clay Math. Inst. (2003), cited 532 times;

"D-branes and Mirror Symmetry," with A. Iqbal and C. Vafa, hep-th/0005247 (2000), cited 434 times;

"Strong coupling dynamics of four-dimensional $N=1$ gauge theories from M theory fivebranes," with H. Ooguri and Y. Oz, Adv. Theor. Math. Phys. (1997), cited 214 times;

"Duality of the fermionic 2d black hole and $N=2$ Liouville theory as mirror symmetry," with A. Kapustin, JHEP (2001), cited 195 times;

"String fluid from unstable D-branes," with G. Gibbons and P. Yi, Nucl. Phys. B (2001), cited 182 times;

"Mirror symmetry in three-dimensional gauge theories, quivers and D-branes," with J. de Boer, H. Ooguri and Y. Oz, Nucl. Phys. B (1997), cited 180 times;

"Elliptic genera of 2d $N=2$ gauge theories," with F. Benini, R. Eager and Y. Tachikawa, Commun. Math. Phys. (2015), cited 158 times;

"Study of $N=2$ superconformal field theories in 4 dimensions," with T. Eguchi, K. Ito and S. Yang, Nucl. Phys. B (1996), cited 179 times;

"Quantum cohomology and Virasoro algebra", with T. Eguchi and C. Xiong, Phys. Lett. B (1997), cited 149 times.

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * **Mikhail Kapranov (55)**

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Professor, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo.

Academic degree and specialty

PhD, Mathematics

Effort 100 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2013-Present: Professor, Kavli IPMU, The University of Tokyo

2003-13: Professor, Yale University

1999-2003: Professor, University of Toronto

1995-99: Professor, Northwestern University

1993-95: Associate Professor, Northwestern University

1991-93: Assistant Professor, Northwestern University

1988-90: Research Associate, Steklov Institute, USSR Academy of Sciences, Moscow

1988: PhD, Steklov Institute

1982: B.S., Moscow University

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Prof. Kapranov 's research is in the areas of algebra, algebraic geometry and category theory.

These areas are the source of powerful conceptual tools for understanding the concept of space in a wide sense, from very classical to very abstract.

For example, the classical subject of hypergeometric functions was developed (in his joint works with I.M. Gelfand and A.V. Zelevinsky) to include period integrals of algebraic hypersurfaces in toric varieties. This led them to the discovery of secondary polytopes, which are combinatorial geometric objects governing both hypergeometric functions and discriminant polynomials in singularity theory. These concepts are now widely used in Mirror Symmetry.

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited Speaker at the International congress of Mathematicians, Berlin 1998.

- b) Member of a scholarly academy in a major country

- c) Recipient of international awards

- d) Editor of an influential journal, etc.

Editor, Duke Mathematical Journal

(2) Receipt of large-scale competitive funds (over the past 5 years)

(3) Article citations (Titles of major publications, number of citations)

"Discriminants, resultants, and multidimensional determinants", Mathematics: Theory & Applications. Birkhäuser Boston, Inc., Boston, MA, 1994. (Research monograph), Gelfand, I. M.; Kapranov, M. M.; Zelevinsky, A. V., cited 789 times.

"Koszul duality for operads", Duke Math. J. 76 (1994), no. 1, 203–272., Ginzburg, Victor; Kapranov, Mikhail, Cited 271 times.

"Representable functors, Serre functors, and reconstructions", Math. USSR-Izv. 35 (1990), no. 3, 519–541. Bondal, A. I.; Kapranov, M. M., Cited 176 times.

"Framed triangulated categories", Math. USSR-Sb. 70 (1991), no. 1, 93–107. Bondal, A. I.; Kapranov, M. M., Cited 138 times.

"Chow quotients of Grassmannians. I.", I. M. Gelfand Seminar, 29–110, Adv. Soviet Math., 16, Part 2, Amer. Math. Soc., Providence, RI, 1993. Kapranov, M. M., Cited 118 times.

"Hypergeometric functions and toric varieties", Funct. Anal. Appl. 23 (1989), no. 2, 94–106. , Gelfand, I. M.; Zelevinsky, A. V.; Kapranov, M. M., Cited 103 times.

"On the derived categories of coherent sheaves on some homogeneous spaces", Invent. Math. 92 (1988), no. 3, 479–508. Kapranov, M. M., Cited 101 times.

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Young-Kee Kim (55)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Louis Block Distinguished Service Professor, The Department of Physics, University of Chicago
Principal Investigator, Kavli Institute for the Physics and Mathematics of the Universe,
The University of Tokyo

Academic degree and specialty

PhD, Physics

Effort 10 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2017-present: Louis Block Distinguished Service Professor, University of Chicago

2017-present Principal Investigator, Kavli Institute for the Physics and Mathematics of
the Universe, University of Tokyo

2016-present: Chair, the Department of Physics, University of Chicago

2012-2016: Louis Block Professor, University of Chicago

2003-Present: Professor of Physics, University of Chicago

2002: Professor of Physics, University of California, Berkeley

2000-2001: Associate Prof. of Physics, Univ. of California, Berkeley

1996-2000: Assistant Prof. of Physics, Univ. of California, Berkeley

Oct. 1990-June 1996: Postdoctoral Fellow / Research Scientist, Lawrence Berkeley National Laboratory

July 2006-June 2013: Deputy Director, Fermilab

1990: Ph.D., Physics, University of Rochester

1986: M.S., Physics, Korea University

1984: B.S., Physics, Korea University

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Prof. Kim is an experimental particle physicist. She has been devoting much of her research to understanding the origin of mass for fundamental particles. Her group measured the mass of two of the most massive particles (the W boson and the top quark) at the Tevatron's CDF experiment,

providing information about the mass of the Higgs boson, discovered at the LHC in 2012. In recent years, her focus has been to (i) find a deeper understanding of the nature of the Higgs, (ii) search for new physics using the Higgs as a new tool, and (iii) search for a new messenger particle that couples to dark matter, using the ATLAS detector at the LHC. Achieving these goals requires significant improvement of detectors and triggers. Her group has been working on the new tracking trigger that has more capability and flexibility than the current trigger system. In addition, her group is exploiting novel concepts in accelerator science and technology, studying limitations affecting the acceleration and intensity of particle beams at a fundamental level, and developing new approaches to overcome these limitations.

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

"Experimental Summary Talk", 37th International Conference on High Energy Physics, July 2-9, 2014, Valencia

Featured guest speaker at the celebration of International Women's Day 2014 at the University of Chicago, March 8, 2014

"Future Neutrino Projects in U.S.", XV International Workshop on Neutrino Telescopes, Venice, Italy, Mar. 14, 2013

"Fermilab: The Next Decade and Beyond", Aspen Conference, Feb. 16, 2012

- b) Member of a scholarly academy in a major country

Fellow, the American Academy of Arts and Sciences (2017)

Fellow, American Association for the Advancement of Science (2012)

- c) Recipient of international awards

2012 Korea University Alumni Award

2012 Leadership Award, Women in Science, Chicago Council of Science and Technology

2010 Rochester Distinguished Scholar Medal, University of Rochester

2008 Science Service Medal, South Korean Government

2005 Ho-Am Prize in Science, Samsung

1999 Professional Opportunities Award for Women in Research and Education, NSF

- d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

(3) Article citations (Titles of major publications, number of citations)

“Evidence for a mass dependent forward-backward asymmetry in top quark pair production”,
By CDF Collaboration (T. Aaltonen et al.), PHYSICAL REVIEW D83, 2011,
DOI:10.1103/PhysRevD.83.112003, cited 278 times.

“Search for new particles decaying into dijets in proton-antiproton collisions at $\sqrt{s}=1.96$ TeV”,
PHYSICAL REVIEW D79, vol11, 2009, By CDF Collaboration (T. Aaltonen et al.), cited 175 times.

“Measurements of the Higgs boson production and decay rates and constraints on its couplings
from a combined ATLAS and CMS analysis of the LHC pp collision data at $\sqrt{s}=7$ and 8 TeV”,
Journal of high energy Physics 8, 2016, by ATLAS Collaborations ; CMS Collaborations (Aad, G
wt al.), cited 99 times.

**(4) Others (Other achievements indicative of the PI's qualification as a top-world
researcher, if any.)**

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Eiichiro Komatsu (43)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Director, Department of Physical Cosmology, Max Planck Institute for Astrophysics

PI, Kavli Institute for the Physics and Mathematics of the Universe, the University of Tokyo

Institutes for Advanced Study, the University of Tokyo

Academic degree and specialty

PhD in Science Degree, Theoretical Physics (Cosmology)

Effort 20 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2017 - Present: Principal Investigator, Kavli IPMU, the University of Tokyo

2010 - 2017: Visiting Senior Scientist, Kavli IPMU, the University of Tokyo

2008 - 2010: Visiting Scientist, Kavli IPMU, the University of Tokyo

2012 - Present: Director, Max Planck Institute for Astrophysics

2010 - 2012: Professor, Department of Astronomy, the University of Texas at Austin

2008 - 2010: Associate Professor, Department of Astronomy, the University of Texas at Austin

2003 - 2008: Assistant Professor, Department of Astronomy, the University of Texas at Austin

2001 - 2003: Postdoctoral Fellow, Department of Astrophysical Sciences, Princeton University

1999 - 2001: Ph.D., Department of Astronomy, Tohoku University

1997 - 1999: M.Sc., Department of Astronomy, Tohoku University

1993 - 1997: B.Sc., Department of Astronomy, Tohoku University

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Prof. Komatsu studies the beginning and an end (if any) of the Universe using the laws of physics and state-of-the-art measurements. He spend 2/3 of his time on theoretical research, and remaining 1/3 on providing theoretical underpinnings to experiments, and analysis and interpretation of the new data. His main weapons are the cosmic microwave background (CMB) and the large-scale structure of the Universe. He was a member of the Wilkinson Microwave Anisotropy Probe (WMAP), with which they determined the age and composition of the Universe. They also found strong evidence for cosmic inflation by discovering adiabatic and

Gaussian super-horizon fluctuations that are nearly, but not exactly, scale invariant. Over the next decade he would like to find definitive evidence for inflation by measuring B-mode polarisation of the CMB, rule out the standard cosmological model (Λ CDM) by mapping cosmic structures up to a redshift of $z=3.5$, and determine the mass of neutrinos. To this end he is co-leading two galaxy surveys with the Prime Focus Spectrograph (PFS) on the Subaru telescope led by the Kavli IPMU, and with the Hobby-Eberly Telescope in the McDonald Observatory. For CMB, he is a member of the LiteBIRD team, and he is leading a team investigating impacts of the Galactic foreground emission on B-mode polarisation. He also enjoys thinking about what new physics they can learn about inflation in case of the discovery of primordial gravitational waves.

Achievements

(1) International influence * Describe the kind of attributes listed below.

a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Keynote, plenary and invited speaker at numerous international conferences such as COSMO, PASCOS, Texas Symposium, etc, at ceremonial conferences such as "Gravity and Blackholes" celebrating the 75th birthday of Stephen Hawking at University of Cambridge, "General Relativity and Gravitation: A Centennial Perspective" the 100th anniversary conference of General Relativity at Penn State University, "Zeldovich 100" the 100th anniversary of Yakov Zeldovich at IKI, Moscow, and the 100th anniversary of the Max Planck Institute for Physics at Munich, as well as at meetings of German Astronomical Society, German Physical Society, American Astronomical Society, Astronomical Society of Japan, and Physical Society of Japan. I was also an invited participant of the 26th Solvay Conference on Physics.

b) Member of a scholarly academy in a major country

Member, German Astronomical Society

Member, American Astronomical Society

Member, American Physical Society

Member, Astronomical Society of Japan

Member, Physical Society of Japan

c) Recipient of international awards

2018 Breakthrough Prize in Fundamental Physics

2015 Fellow of American Physical Society

2015 Chushiro Hayashi Prize of the Astronomical Society of Japan

2013 Lancelot M. Berkeley Prize of the American Astronomical Society

2012 Gruber Cosmology Prize

2010 Nishinomiya-Yukawa Memorial Prize

2008 Young Physicist's Prize of the International Union of Pure and Applied Physics

2005 Alfred P. Sloan Research Fellow

d) Editor of an influential journal, etc.

Editorial Board, *Astronomy and Astrophysics Review*

Editor, Journal of Cosmology and Astro-particle Physics

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in-Aid for Scientific Research on Innovative Areas (FY2015-), Co-PI: Grant Title: "Why is the Universe accelerating?"

(3) Article citations (Titles of major publications, number of citations)

"Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation", ApJS, 192, 18 (2011), Komatsu et al., cited 6167 times

"Five-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation", ApJS, 180, 330 (2009), Komatsu et al., cited 4618 times

"Acoustic signatures in the primary microwave background bispectrum", Phys. Rev. D. 63, 063002 (2001), Komatsu and Spergel, cited 763 times

"First-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Tests of Gaussianity", ApJS, 148, 119 (2003), Komatsu et al., cited 498 times

"The Sunyaev-Zeldovich angular power spectrum as a probe of cosmological parameters", MNRAS, 336, 1256 (2002), Komatsu and Seljak, cited 292 times

"Measuring primordial non-Gaussianity in the cosmic microwave background", ApJ, 634, 14 (2005), Komatsu, Spergel, and Wandelt, cited 207 times

"Hunting for primordial non-Gaussianity in the cosmic microwave background", Class. Quant. Grav., 27, 124010 (2010), Komatsu, cited 188 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Organized a large international symposium on "Theoretical and Observational Progress on the Large-scale Structure of the Universe" at European Southern Observatory in July, 2015, attracting 188 participants from all over the world

Serving/served on external advisory committees for Canadian Institute for Advanced Research (CIFAR), Scuola Internazionale Superiore di Studi Avanzati (SISSA), and the Simons Observatory project

Served on Science Organizing Committees of numerous international conferences in USA, Germany, Japan, India, Spain, Italy, the Netherlands, Switzerland, Israel, and Croatia

Selected as "Highly Cited Researcher" by Thomson Reuters/Creative Analytics

According to Thomson Reuters, Komatsu et al., "Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation", ApJS, 192, 18 (2011) and Komatsu et al., "Five-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation", ApJS, 180, 330 (2009) are the most highly cited papers in all sciences in 2011 and 2009, respectively.

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Kai Martens (54)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Associate Professor, Kavli Institute for the Physics and Mathematics of the Universe,
The University of Tokyo Institutes for Advanced Study, The University of Tokyo

Academic degree and specialty

Ph.D., Experimental Neutrino Physics, Dark Matter Direct Detection

Effort 80 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2008 – present: Associate Professor, Kavli IPMU, The University of Tokyo

2008 – 2008: Associate Professor, Department of Physics, University of Utah

2000 – 2008: Assistant Professor, Department of Physics, University of Utah

1998 – 2000: Consultant, Department of Physics and Astronomy, SUNY at Stony Brook

1996 – 1998: JSPS fellow, ICRR, The University of Tokyo

1995 – 1996: COE fellow, ICRR, The University of Tokyo

1989 – 1994: PhD, Physikalisches Institut, Heidelberg University

1987 – 1989: Diplom, Physikalisches Institut, Heidelberg University

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

In 1998 his group found evidence for neutrino oscillations with Super-Kamiokande. In 2008 they reported the "First Observation of the Greisen-Zatsepin-Kuzmin Suppression" with the High Resolution Fly's Eye (HiRes) experiment.

Achievements

(1) **International influence** * Describe the kind of attributes listed below.

a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Lecturer on "Nonaccelerator-Based Neutrino Oscillation Experiments" at the 1997 SLAC Summer Institute.

One of three organizers of the 2002 Aspen Winter Conference on "Ultra High Energy Particles from

Space”

b) Member of a scholarly academy in a major country

c) Recipient of international awards

2016 Breakthrough Prize in Fundamental Physics as member of the Super-Kamiokande and K2K teams

1998 Asahi Prize for Science as a member of the Super-Kamiokande collaboration

d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

(3) Article citations (Titles of major publications, number of citations)

“Evidence for Oscillation of Atmospheric Neutrinos”, Y. Fukuda et al. (Super-Kamiokande Collaboration), Phys. Rev. Lett. 81 (1998) 1562, 2570 citations

“First Observation of the Greisen-Zatsepin-Kuzmin Suppression”, R.U. Abbasi et al. (High Resolution Fly's Eye Collaboration), Phys. Rev. Lett. 100 (2008) 101101, 355 citations

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Shigeki Matsumoto (45)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Associate Professor, Kavli Institute for the Physics and Mathematics of the Universe,
The University of Tokyo Institutes for Advanced Study, The University of Tokyo

Academic degree and specialty

Ph.D., Particle Physics (Phenomenology)

Effort 80%

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

- 6/2015—Present: Associate Professor at Kavli IPMU
- 10/2010—5/2015: Research Associate Professor at Kavli IPMU
- 4/2008—9/2010: Associate Professor at U. Toyama
- 4/2007—3/2008: Assistant Professor at Tohoku U.
- 4/2005—3/2007: Post doctorate research fellow at KEK
- 4/2003—3/2005: Post doctorate research fellow at ICRR
- 4/2000—3/2003: JSPS Fellow (PD) at KEK & ICRR
- 4/1998—3/2000: JSPS Fellow (DC2) at Tohoku U.

- 3/2000: Doctor of Science (Physics) obtained at Tohoku U.
- 3/1997: Master of Science (Physics) obtained at Tohoku U.
- 3/1995: Bachelor of Science (Physics) obtained at Tohoku U.

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

The dark matter problem of the universe is very important not only for particle physics but also astrophysics and cosmology. Thanks to recent cosmological observations, the existence of dark matter has been established, however, its nature has not been revealed yet. Prof. Matsumoto has researched the nature of dark matter from the viewpoint of new physics at the TeV scale. To be more precisely, he has studied how dark matter can be detected in collider experiments (LHC and ILC) and detection measurements based on several new physics models such as the supersymmetric model, the little higgs model with T-parity, and the universal extradimension

model. As an advanced topic of these studies, he would like to establish a method to clarify the nature of dark matter in a model-independent fashion. In addition to the topic related to dark matter, he is also planning to study the first order phase transition and the non-equilibrium dynamics of elementary particles in the early universe.

Achievements

(1) International influence * Describe the kind of attributes listed below.

a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited speaker many times at various international conferences such as PHENO, COSMO, PLANCK, DSU, CosPA, ACFA, SI, KEKPH, JPS symposium

b) Member of a scholarly academy in a major country

Member of Review committee on 250GeV International Linear Collider

Committee member of KEK theory center project (Energy frontier & Flavor experiment for BSM)

Committee member of future projects for Japan Association of High Energy Physicists (JAHEP)

Member of physics working group at KEK promotion office for ILC

Member of physics working group at MEXT council for ILC

Editorial member of JPS magazine

Committee member of Japan Particle and Nuclear Theory Forum

Member of the JPS

c) Recipient of international awards

2007 Particle Physics Medal: Young Scientist Award in Theoretical Particle Physics

d) Editor of an influential journal, etc.

None

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in-Aid for Scientific Research (B), April 2017—May 2022, 5 MJPY.

“Experimental test of High-scale supersymmetric model” (Co-Investigator)

Grant-in-Aid for Scientific Research (A), April 2016—May 2020, 43 MJPY.

“Dark matter search at future lepton colliders” (Principal Investigator)

Grant-in-Aid for Scientific Research (B), April 2014—May 2017, 3 MJPY.

“Phenomenological study of High-scale supersymmetric model” (Co-Investigator)

Grant-in-Aid for Scientific Research of Innovative areas, April 2014—May 2019, 4 MJPY.

“The origin of matter and the evolution of the universe”, (Co-Investigator)

Grant-in-Aid for Scientific Research (A), April 2010—May 2014, 5 MJPY.

“New particle physics models and cosmological scenarios based on LHC” (Co-Investigator)

(3) Article citations (Titles of major publications, number of citations)

“Non-perturbative effect on thermal relic abundance of dark matter”

J. Hisano, S. Matsumoto, M. Nagai, O. Saito and M. Senami, PLB646, 34-38, 2007. (cited 414 times)

“Explosive dark matter annihilation”

J. Hisano, S. Matsumoto and M. M. Nojiri, PRL92, 031303, 2004. (cited 336 times)

“Non-perturbative effect on thermal relic abundance of dark matter”

J. Hisano, S. Matsumoto, M. Nagai, O. Saito and M. Senami, AIP Conf. Proc. 957, 401, 2007. (cited 302 times)

“Pure gravity mediation with $m_{3/2} = 10\text{--}100\text{ TeV}$ ”

M. Ibe, S. Matsumoto and T. T. Yanagida, PRD85, 095011, 2012. (cited 169 times)

“Can WIMP dark matter overcome the nightmare scenario?”

S. Kanemura, S. Matsumoto, T. Nabeshima and N. Okada, PRD82, 055026, 2010. (cited 150 times)

“Cosmic-Ray Positron from Superparticle Dark Matter and the PAMELA Anomaly” K. Ishiwata, S. Matsumoto and T. Moroi, PLB675, 446-449, 2009. (cited 131 times)

“Heavy wino-like neutralino dark matter annihilation into antiparticles”

J. Hisano, S. Matsumoto, O. Saito and M. Senami, PRD73, 055004, 2006. (cited 131 times)

“Neutrinos at IceCube from Heavy Decaying Dark Matter”

B. Feldstein, A. Kusenko, S. Matsumoto and T. T. Yanagida, PRD88, 015004, 2013. (cited 119 times)

“High Energy Cosmic Rays from Decaying Supersymmetric Dark Matter” K. Ishiwata, S. Matsumoto and T. Moroi, JHEP0905, 110, 2009. (cited 117 times)

“Unitarity and higher-order corrections in neutralino DM annihilation into two photons”

J. Hisano, S. Matsumoto and M.M. Nojiri, PRD67, 075014, 2003. (cited 109 times)

(4) Others (Other achievements indicative of the PI’s qualification as a top-world researcher, if any.)**TAUP 2019**

Organizer, Toyama Japan, September 9-13, 2019.

ALCW2018

Convener, Kyushu U. Japan, May 26—June 1, 2018.

TeVPA 2015

Organizer, U. Tokyo Japan, October 26—30, 2015.

ECFA LC2013

Convener, DESY Germany, May 27—31, 2013.

LCWS2011

Convener, Granada U. Spain, September 26—30, 2011.

LCWS2010

Convener, Beijing China, March 26—30, 2010.

LCWS2008

Program committee member, Illinois U. USA, November 16—20, 2008.

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Shigetaka Moriyama (48)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Professor

Kamioka Observatory, Institute for Cosmic Ray Research, the University of Tokyo

Academic degree and specialty

Ph. D

Experimental physics (Astroparticle Physics)

Dark Matter Physics, Neutrino physics, Axion and exotics

Effort 20 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2017-: Professor, Kamioka Observatory, ICRR, the University of Tokyo

2003-2017: Associate Professor, Kamioka Observatory, ICRR, the University of Tokyo

1999-2003: Assistant Professor, Kamioka Observatory, ICRR, the University of Tokyo

1998-1999: JSPS PD research fellowship

1992-1998: Ph.D. Phys. Dept. the University of Tokyo

1988-1992: B.A. Phys. Dept., the University of Tokyo

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Dr. Moriyama is currently leading a direct dark matter search experiment, XMASS, at Kamioka Observatory as a spokesperson of the project. He successfully led construction and operation of a past prototype detector as well as the XMASS-I detector, as a scientific leader at the construction site. He also led collaborators to identify a cause of the background seen at commissioning data of the XMASS-I detector and to achieve a scientific goal of the detector, a dark matter search in a fiducial volume of it. Before appointed as the spokesperson, he was working as a convener of the analysis group and playing the major role of it. He proposed research topics and led to produce important scientific achievements: the search for ^{129}Xe inelastic scattering, solar axion, and bosonic super-WIMPs. This extended scientific reach of the XMASS project.

He is also deeply interested in neutrino physics and nucleon decay experiments. He has long experience with the water Cherenkov detector, Super-Kamiokande, as a convener of the

calibration group. He is now playing an important role in the Hyper-Kamiokande project as a technical coordinator of the project and as a member of the steering committee of Next generation Neutrino Science Organization (NNSO).

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

- b) Member of a scholarly academy in a major country
 Science Advisory Committee member of the Low Radioactivity Techniques workshop
 Convener of the ICHEP2016 conference for dark matter session
 Member of the committee on Future Projects in High Energy Physics in Japan

- c) Recipient of international awards
 2016 Breakthrough Prize

- d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in Aid Scientific Research A (FY2012-2014), co-PI: Grant Title "A Search for Dark Matter"

(3) Article citations (Titles of major publications, number of citations)

"Search for bosonic superweakly interacting massive dark matter particles with the XMASS-I detector", XMASS collaboration, PRL 113 (2014) 121301, 33 citations
 "Search for inelastic WIMP nucleus scattering on ^{129}Xe in data from the XMASS-I experiment", XMASS collaboration, PTEP, 2014 (2014) 063C01, 12 citations
 "Search for solar axions in XMASS, a large liquid xenon detector", XMASS collaboration, PLB 724(2013) 46, 50 citations
 "A proposal to search for monochromatic component of solar axions using Fe-57 ", S. Moriyama, PRL 75 (1995) 3222, 57 citations
 "Calibration of the Super-Kamiokande detector", Super-Kamiokande collaboration, NIMA A737 (2014) 253-272, 70 citations
 "Atmospheric neutrino oscillation analysis with sub-leading effects in Super-Kamiokande I, II, and III", Super-Kamiokande collaboration, PRD 81 (2010) 092004, 311 citations

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any).

Appendix 2a Biographical Sketch of Principal Investigator

Name (Age) * Yasunori Nomura (44)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Principal Investigator, Kavli Institute for the Physics and Mathematics of the Universe,
The University of Tokyo Institutes for Advanced Study, The University of Tokyo

Director, Berkeley Center for Theoretical Physics, University of California, Berkeley

Professor, Department of Physics, University of California, Berkeley

Senior Faculty Scientist, Physics Division, Lawrence Berkeley National Laboratory

Academic degree and specialty

Ph. D.

Quantum Gravity, Cosmology, Particle Physics Theory

Effort 15%

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2017 – present: Principal Investigator, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo

2015 – present: Director, Berkeley Center for Theoretical Physics,
University of California Berkeley

2012 – present: Professor of Physics, University of California, Berkeley

2008 – present: Senior Faculty Scientist, Lawrence Berkeley National Laboratory

2015, 2016, 2017: Project Professor, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo

2015 – 2017: Visiting Senior Scientist, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo

2012 – 2013: Visiting Professor, Massachusetts Institute of Technology

2010 – 2014: Visiting Scientist, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo

2010: Adjunct Professor, Tohoku University

2007 – 2012: Associate Professor, University of California, Berkeley

2003 – 2008: Physicist Faculty, Lawrence Berkeley National Laboratory

2003 – 2007: Assistant Professor, University of California, Berkeley

2002 – 2003: Associate Scientist, Fermi National Accelerator Laboratory

2000 – 2002: Miller Research Fellow, University of California, Berkeley

1998 – 2000: Ph.D. (Doctor of Science), Department of Physics, The University of Tokyo

1996 – 1998: Master of Science, Department of Physics, The University of Tokyo

1992 – 1996: B.A., Department of Physics, The University of Tokyo

Achievements and highlights of past research activities

Prof. Nomura is a theoretical physicist, working mainly on particle physics and cosmology. In the past two decades, our understanding of the universe has improved dramatically, which includes the Nobel awarded discovery of the accelerated expansion. Also, recent progresses in quantum gravity are revealing remarkable natures of spacetime and gravity, beyond what we can learn from quantum field theory in curved spacetime. These new developments together suggest a surprising picture of the “quantum multiverse”: our universe may be one of the many universes in which low energy physical laws take different forms, and that quantum mechanics plays a crucial role in describing these many universes even at the largest distance scales. He is pursuing what this new picture implies for fundamental aspects of quantum gravity as well as for future cosmological observations. He also studies related questions in quantum gravity, such as the information problem in black hole physics.

Achievements

(1) International influence

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited plenary speakers at many major international conferences and workshops, including Moriond, PASCOS, SUSY, Planck, Gordon Research, PHENO, and NNN conference series.

- b) Member of a scholarly academy in a major country

Elected Fellow, American Physical Society (APS)

Member, The Foundational Questions Institute (FQXi)

- c) Recipient of international awards

2017 American Physical Society Fellow

2012 Simons Fellow in Theoretical Physics

2005 Hellman Family Faculty Fund Award

2005 Alfred P. Sloan Research Fellowship

2004 Outstanding Junior Investigator Award, US Department of Energy

2000 Miller Research Fellow

1998 Research Fellow of the Japan Society for the Promotion of Science

- d) Editor of an influential journal, etc.

Editorial Board, *Symmetry* (ISSN 2073-8994)

Scientific Advisory Board, Multiversal Journeys—A 501(c) (3) Non-Profit Organization

(2) Receipt of large-scale competitive funds (over the past 5 years)

MEXT KAKENHI grant 15H05895 (FY2015 –), co-PI: Grant Title “Why does the universe accelerate?—exhaustive study and challenge for the future”

National Science Foundation grant PHY-1521446 (2015 –), co-PI: Grant Title “Particles and strings in the evolving universe”

(3) Article citations (Titles of major publications, number of citations)

- "Constrained standard model from a compact extra dimension,"
with R. Barbieri and L.J. Hall, Phys. Rev. D63 (2001) 105007, cited 276 times
- "Gauge unification in higher dimensions,"
with L.J. Hall, Phys. Rev. D64 (2001) 055003, cited 508 times
- "Unification of Higgs and gauge fields in five dimensions,"
with G. Burdman, Nucl. Phys. B656 (2003) 3, cited 214 times
- "Higgs as a holographic pseudo-Goldstone boson,"
with R. Contino and A. Pomarol, Nucl. Phys. B671 (2003) 148, cited 527 times
- "Supersymmetry, naturalness, and signatures at the LHC,"
with R. Kitano, Phys. Rev. D73 (2006) 095004, cited 266 times
- "Dark matter through the axion portal,"
with J. Thaler, Phys. Rev. D79 (2009) 075008, cited 224 times
- "Physical theories, eternal inflation, and the quantum universe,"
JHEP 11 (2011) 063, cited 58 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

- Program Committee, "The 14th International Conference on Supersymmetry and the Unification of Fundamental Interactions (SUSY 06)," Irvine, California, June 12 – 17, 2006.
- Co-convener, "The 15th International Conference on Supersymmetry and the Unification of Fundamental Interactions (SUSY 07)," Karlsruhe, Germany, July 26 – August 1, 2007.
- Organizer, ASPEN Summer 2008 Workshop "Supersymmetry Breaking and its Mediation in Field Theory and String Theory," Aspen Center for Physics, Colorado, June 22 – July 20, 2008.
- Co-convener, "2009 Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2009)," Wayne State University, Detroit, Michigan, July 26 – 31, 2009.
- Chair of the Organizing Committee, "Embarking on a New Era of Discovery: LHC, Dark Matter, and their interplay," UC Berkeley, California, April 29 – May 1, 2011.
- Organizer, KITP Workshop "The First Year of the LHC," Kavli Institute for Theoretical Physics, UC Santa Barbara, California, June 6 – August 26, 2011.
- Organizer, GGI Workshop "Beyond the Standard Model after the First Run of the LHC," Galileo Galilei Institute for Theoretical Physics, Florence, Italy, May 20 – July 12, 2013.
- Organizer, Breakthrough Prize Fundamental Physics Symposium, Stanford University, California, November 10, 2014.
- Organizer, "Summer School on Particle Physics," The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, June 15 – 26, 2015.
- Selection Committee, the "Best Paper Award" for Symmetry (ISSN 2073-8994), 2015.
- Scientific Organizing Committee, "Lattice for Beyond the Standard Model Physics 2017," Boston University, Massachusetts, April 20 – 21, 2017.
- Scientific Committee, "Symmetry 2017– The First International Conference on Symmetry," Barcelona, Spain, October 16 – 18, 2017.

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Masahiro Takada (44)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

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

Academic degree and specialty

Ph.D., Astronomy

Effort 80 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2013 – Present: Professor, Kavli IPMU, The University of Tokyo

2012 – 2013: Project Professor, Kavli IPMU, The University of Tokyo

2008 – 2012: Project Associate Professor, Kavli IPMU, The University of Tokyo

2008 – 2004: Assistant Professor, Tohoku University

2002 – 2004: Postdoctoral Researcher, Dept. of Physics and Astronomy, University of Pennsylvania

2001 – 2002: JSPS Fellow, National Astronomical Observatory of Japan

1996 – 2001: Ph.D., Astronomical Institute, Tohoku University

1992 – 1996: B.A., Phys. Dept., Tohoku University

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Masahiro Takada has been one of the core members for the international collaboration for the Subaru Hyper Suprime-Cam project and the Subaru Prime Spectrograph project. Takada proposed a cosmological method combining different cosmological observables (weak lensing, galaxy clustering, redshift-space distortion) to obtain robust and precise constraints on cosmological parameters such as the dark energy parameters and neutrino mass. Takada and his collaborators applied the methods to actual data such as the SDSS and Subaru data to constrain the parameters of structure formation models. Takada and his collaborator used the Subaru HSC data of the Andromeda galaxy to search for microlensing events due to primordial black holes (PBHs) of lunar mass scales, and then derived the most stringent upper limit on the abundance of such PBHs compared to the previous constraints.

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited or keynote speaker at many international conferences such as "Cross-correlation Spectacular with LSST: Exploring Synergies Between LSST and External Datasets to Discover Fundamental Physics" (BNL, 2016), "Cosmology and First Light" (Paris, 2015), "IAU Symposium 306: Statistical challenges in 21st century cosmology" (Lisbon, 2014)

- b) Member of a scholarly academy in a major country

Member of TMT Japan Advisory Committee (FY2017 – present)

Member of Subaru Advisory Committee (FY2010 - 2016)

- c) Recipient of international awards

- d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in Aid for Scientific Research on Innovative Areas (FY2015-), PI: Grant Title "Exploring Cosmic Acceleration with Wide-field Redshift Galaxy Survey"

Scientific Research B (FY2015-), PI: Grant Title "Precision Cosmology with Subaru Wide-Field Galaxy Survey"

(3) Article citations (Titles of major publications, number of citations)

"Systematic errors in future weak-lensing surveys: requirements and prospects for self-calibration", MNRAS (2006), cited 256 times

"Cosmological parameters from lensing power spectrum and bispectrum tomography", MNRAS (2004), cited 242 times

"LoCuSS: Subaru Weak Lensing Study of 30 Galaxy Clusters", Publ. Astron. Soc. Japan, cited 227 times

"Extragalactic science, cosmology, and Galactic archaeology with the Subaru Prime Focus Spectrograph", Publ. Astron. Soc. Japan, cited 162 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Project Scientist of the Subaru Prime Focus Spectrograph project (international collaboration)

Co-chair of the Subaru Hyper Suprime-Cam Science Working Group (international collaboration)

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Yukinobu Toda (38)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Professor, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo Institutes for Advanced Study, The University of Tokyo

Academic degree and specialty

Ph.D., Mathematics

Effort 80 %

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2017 July-, Full professor, Kavli IPMU, University of Tokyo.

2017 April-, Principal investigator, Kavli IPMU, University of Tokyo.

2015 June-, Associate professor, Kavli IPMU, University of Tokyo.

2012 Apr-2015 May, Project Associate professor, Kavli IPMU, University of Tokyo.

2008 Nov-2012 Mar, Project Associate professor, IPMU, University of Tokyo.

2008 Jan-2008 Oct, Project Assistant professor, IPMU, University of Tokyo.

2006 Apr-2007 Dec, JSPS postdoc fellow at Mathematical Sciences, University of Tokyo.

2002 Apr-2006 Mar, Ph.D. Graduate School of Mathematical Sciences, University of Tokyo.

1998 Apr-2002 Mar, B.A. Graduate School of Mathematical Sciences, University of Tokyo.

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Algebraic varieties are geometric objects defined by zero locus of polynomials, and their properties have been studied for a long time in the form of such familiar shapes as parabolas and circles. On the other hand, a special class of algebraic varieties called Calabi-Yau manifolds is playing an important role in modern superstring theory, in which an interesting conjecture called mirror symmetry has been proposed. This conjecture claims that there should exist a symmetry between two different mathematical objects (algebraic varieties and symplectic manifolds), and now this conjecture is described by an abstract notion of triangulated categories. Triangulated categories corresponding to algebraic varieties are derived categories of coherent sheaves, and Prof. Toda has been studying derived categories.

His recent works are descriptions of the spaces of stability conditions on certain derived categories, and constructions of the moduli spaces of (semi) stable objects on them. Here the notion of stability conditions is considered to give a mathematical framework of BPS-branes in superstring theory, and we can observe several interesting symmetries other than mirror symmetry by studying derived categories and stability conditions on them. He believes that we can understand such symmetries uniformly, by establishing a new geometry based on derived categories, and developing the theory of stability conditions.

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Invited speaker at the International Congress of Mathematicians (ICM), 2014, Seoul.

- b) Member of a scholarly academy in a major country

- c) Recipient of international awards

2015, JSPS prize

2014, MSJ Spring prize

2012, MSJ Geometry prize

- d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in-Aid for Scientific Research B (FY 2014-), PI: The study of stability conditions on derived categories and Donaldson-Thomas invariants

(3) Article citations (Titles of major publications, number of citations)

"Curve counting theories via stable objects I, DT/PT correspondence", Journal of the American Mathematical Society (2010), cited 38 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Mark Robert Vagins (52)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

Professor, Kavli Institute for the Physics and Mathematics of the Universe,
The University of Tokyo Institutes for Advanced Study, The University of Tokyo

Academic degree and specialty

Ph.D., High Energy Physics, Experimental Physics, Neutrino Astrophysics

Effort 80%

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2013 – Present: Adjunct Professor of Physics; University of California, Irvine
 2008 – Present: Professor of Physics, Kavli IPMU, University of Tokyo
 2001 – 2013: Associate Research Physicist; University of California, Irvine
 1997 – 2001: Assistant Research Physicist; University of California, Irvine
 1996 – 1997: Distinguished Visiting Scientist; University of California, Irvine
 1995 – 1995: Lecturer, Louisiana State University
 1994 – 1997: Postdoctoral Researcher, Louisiana State University
 1989 – 1994: Ph.D., Physics Department, Yale University
 1987 – 1989: M.Phil, Physics Department, Yale University
 1987 – 1989: M.S., Physics Department, Yale University
 1983 – 1987: B.S.; Division of Physics, Math, and Astronomy; California Institute of Technology

Achievements and highlights of past research activities

* Describe the PI's qualifications as a top-caliber researcher if s/he is considered to be ranked among the world's top researchers.

Having spent fourteen years working on neutrino experiments in Japan — and the last decade as the American convener of Super-Kamiokande's solar and supernova neutrino group — Prof. Vagins is honored and excited to join IPMU as its first full-time foreign professor.

His research is focused on developing new methods of observing neutrinos, both through the enhancement of existing detectors like Super-Kamiokande (Super-K) and via the design and construction of future facilities. One of his main goals is to measure, for the first time, the diffuse supernova neutrino background (DSNB), often called the "relic" supernova neutrinos. Supernova explosions have been going on since the start of star formation, and the neutrinos from all of these historical supernovas now fill space. Measuring this DSNB will tell them much about the evolution of the universe, the average rate of star formation, and even the lifetime of the neutrino.

Adding water-soluble gadolinium to Super-K should allow them to detect these relic neutrinos without having to build an all-new experiment. Enhancing Super-K in this manner will also make possible other new physics, including high-statistics reactor antineutrino oscillation studies. His work at the Institute will be focused on making these new measurements a reality.

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Keynote, Invited speaker many times at international conferences such as NEUTRINO, TeVPA, NNN, AAP, AAAS, HANSE, LowNu, WHEPP, PACIFIC, SnowPAC, JGRG

- b) Member of a scholarly academy in a major country

Member of the American Physics Society

- c) Recipient of international awards

2016 Breakthrough Prize in Fundamental Physics (double recipient)

2012 Le Prix La Recherche

1998 Asahi Prize

- d) Editor of an influential journal, etc.

(2) Receipt of large-scale competitive funds (over the past 5 years)

Grant-in-Aid for Scientific Research on Innovative Areas (2017-), PI, Gravitational Wave Physics and Astronomy: Genesis

Grant-in-Aid for Scientific Research on Innovative Areas (2012-2017), PI, New Developments in Astrophysics Through Multi-Messenger Observations of Gravitational Wave Sources

(3) Article citations (Titles of major publications, number of citations)

"Combined Analysis of Neutrino and Antineutrino Oscillations at T2K", K. Abe et al., (The T2K Collaboration), *Physical Review Letters* 118 151801 (2017) [arXiv:1701.00432 [hep-ex]], cited 63 times

"Observing the Next Galactic Supernova," S. M. Adams, C. S. Kochanek, J. F. Beacom, M. R. Vagins, K. Z. Stanek, *Astrophysical Journal* 778, 164 (2013) [arXiv:1306.0559 [astro-ph.HE]], cited 66 times

"Indication of Electron Neutrino Appearance from an Accelerator-produced Off-axis Muon Neutrino Beam," K. Abe et al. (The T2K Collaboration), *Physical Review Letters* 107:041801 (2011) [arXiv:1106.2822 [hep-ex]], cited 1350 times

"Solar Neutrino Measurements in Super-Kamiokande-I," J. Hosaka et al. (The Super-K Collaboration), *Physical Review D* 73, 112001 (2006) [hep-ex/0508053], cited 537 times

"GADZOOKS! Antineutrino Spectroscopy with Large Water Cherenkov Detectors," J. F. Beacom and M. R. Vagins, *Physical Review Letters* 93, 171101 (2004) [hep-ph/0309300], cited 320 times

"Evidence for oscillation of atmospheric neutrinos," Y. Fukuda et al. (The Super-K Collaboration), *Physical Review Letters* 81, 1562-1567 (1998) [hep-ex/9807003], cited 5416 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

2016 – present: co-spokesperson; WATCHMAN/Advanced Instrumentation Testbed(AIT)

2014 – present: Member of the SNOLAB Experimental Advisory Committee

2014 – present: leader and co-convener; Super-Kamiokande's gadolinium group

2009 – present: designer and leader; EGADS gadolinium R&D project

2006 – present: inventor and developer of selective molecular band-pass filtration

2003 – present: co-inventor and leading worldwide proponent of gadolinium-loaded water Cherenkov detectors

1998 – 2014: co-convener; Super-Kamiokande's solar and supernova neutrino group

Appendix 2a Biographical Sketch of Principal Investigator

(within 3 pages per person)

Name (Age) * Naoki Yoshida (44)

* Place an asterisk (*) by the name of the principal investigators who are considered to be ranked among the world's top researchers.

Affiliation and position (Position title, department, organization, etc.)

PI, Kavli IPMU

Professor, Department of Physics, University of Tokyo

Principal Investigator, Japan Science and Technology Agency

Academic degree and specialty

PhD

Cosmology, Astrophysics, Computational Physics

Effort 40%

* Percentage of time that the PI will devote to his/her work for the center vis-à-vis his/her total working hours (total time for whole working activities including education, medical services, and others as well as research).

Research and education history

2012-2014: Guest Professor, ISAS, Japan Aerospace Exploration Agency

2008-2012: Associate Professor, Kavli IPMU, The University of Tokyo

2004-2008: Assistant Professor, Department of Physics, Nagoya University

2003: Japan Society for the Promotion of Science SPD Fellow, NAOJ

2001-2003: Postdoctoral Fellow, Harvard-Smithsonian Center for Astrophysics

Education

1998-2001: **Max-Planck-Institut fuer Astrophysik, Germany**

PhD in Astronomy

1997-1998: **Royal Institute of Technology, Sweden**

Teknologie Licentiat in Applied Mathematics

1996-1998: **University of Tokyo, Japan**

MSc in Aerospace Engineering

1992-1996: **University of Tokyo, Japan**

BSc in Aerospace Engineering

Achievements and highlights of past research activities

Numerical simulations of the formation of the first generation of stars and blackholes in the Universe

Statistical Computational Cosmology

Achievements

(1) International influence * Describe the kind of attributes listed below.

- a) Guest speaker or chair of related international conference and/or director or honorary chairman of a major international academic society in the subject field

Many keynote and invited talks including

2017 Plenary Talk at IEEE International workshop on machine learning and signal processing (Tokyo)

2016 Invited Talk at Star Formation Conference at KITP (USA)

2015 Plenary Talk at Olympia Symposium (Greece)

2014 CRA Distinguished Lecturer, Georgia Institute of Technology

- b) Member of a scholarly academy in a major country

Astronomical Society of Japan

- c) Recipient of international awards

2017 Japan Academy Medal

2009 Beatrice M. Tinsley Research Scholar, University of Texas at Austin

2008 International Union of Pure and Applied Physics Young Scientist Prize

- d) Editor of an influential journal, etc.

Editorial Board, Scientific Reports by Nature Publishing Group

(2) Receipt of large-scale competitive funds (over the past 5 years)

2014-present JST CREST

2015-present SPPEXA (German-French-Japanese Research Fund for Exascale Computing)

(3) Article citations (Titles of major publications, number of citations)

"GADGET: a code for collisionless and gasdynamical cosmological simulations"

V Springel, N Yoshida, SDM White, *New Astronomy* 6 (2), 79-117, cited 1600 times

"Simulations of early structure formation: primordial gas clouds", N Yoshida, T Abel, L

Hernquist, N Sugiyama, *The Astrophysical Journal* 592 (2), 645, cited 450 times

"Formation of primordial stars in a Λ CDM universe", N Yoshida, K Omukai, L Hernquist, T Abel

The Astrophysical Journal 652 (1), 6, cited 410 times

(4) Others (Other achievements indicative of the PI's qualification as a top-world researcher, if any.)

Appendix 3-1 FY 2017 Records of Center Activities

1. Researchers and center staffs, satellites, partner institutions

1-1. Number of researchers in the "core" established within the host institution

- Regarding the number of researchers at the Center, please fill in the table in Appendix 3-1a.

Special mention

- Enter matters warranting special mention, such as concrete plans for achieving the Center's goals, established schedules for employing main researchers, particularly principal investigators.

The Kavli IPMU proceeds to increase and rejuvenate PIs in the extension period starting from FY2017. The lineup of new PIs on site is K. Hori, K. U. Martens, S. Matsumoto, S. Moriyama, M. Takada, Y. Toda, M. Vagins, and N. Yoshida. The other PIs are Y. K. Kim, a leader on the LHC experiment, to build closer collaborations between experimentalists and theorists; E. Komatsu to launch new initiatives such as LiteBIRD; Y. Nomura, who works at the Berkeley satellite to strengthen ties between research at Tokyo and Berkeley; M. Kapranov, who was attracted from Yale University as a professor of Kavli IPMU and opens a new dimension to mathematics research. The number of PIs has increased to 26 and their average age is 53 (7 years younger than previous PIs at the end of FY2016) as of 2018.

- As background to how the Center is working on the global circulation of world's best brains, give good examples, if any, of how career paths are being established for the Center's researchers; that is, from which top-world research institutions do researchers come to the Center and to which research institutions do the Center's researchers go, and how long are their stays at those institutions.

By the end of FY 2017, we hired 13 postdoctoral researchers and 11 had left Kavli IPMU. The hired postdocs came from different foreign university/institutes including UCLA, UC San Diego, U Illinois Urbana-Champaign, Max-Planck Institute for Nuclear Physics, King's College London, Durham U, U Sydney, U Milano-Bicocca. Out of 11 postdocs who left Kavli IPMU during FY 2017, 4 assumed faculty positions including an associate professor position in Sun Yat-sen University, lecturer position in Chulalongkorn U, assistant professor position in Kyushu U and assistant professor position in ICRR, 4 moved to another appointment including U Arizona, DESY, and RIKEN.

1-2. Satellites and partner institutions

- List the satellite and partner institutions in the table below.

- Indicate newly added and deleted institutions in the "Notes" column.

- If satellite institutions have been established, describe by satellite the Center's achievements in coauthored papers and researcher exchanges in Appendix 4.

<Satellite institutions>

| Institution name | Principal Investigator(s), if any | Notes |
|-----------------------------------|--------------------------------------|-------|
| University of California Berkeley | Hitoshi Murayama, Yasunori Nomura | |
| | | |

< Partner institutions >

| Institution name | Principal Investigator(s), if any | Notes |
|--|-----------------------------------|-------|
| Institut des Hautes Études Scientifiques (IHES) | | |
| Kyoto University, Yukawa Institute for Theoretical Physics | | |
| Kyoto University, Department of Physics | | |
| High Energy Accelerator Research Organization (KEK) | Mihoko Nojiri | |
| National Astronomical Observatory in Japan (NAOJ) | | |
| Princeton University, Department of Astrophysical Sciences | David Spergel | |
| Tohoku University, Research Center for Neutrino Science | Kunio Inoue | |

2. Securing external research funding*

External research funding secured in FY2017

Total: 1,282,631,000 yen

- Describe external funding warranting special mention. Include the name and total amount of each grant.

* External research funding includes "Grant-in-Aid for Scientific Research," funding for "commissioned research projects," and for "joint research projects" as listed under "Research projects" in Appendix 3-2, Project Expenditures.

- Japan Society for the Promotion of Science (JSPS)
Scientific Research on Innovative Areas "Why does the Universe accelerate? –Exhaustive study and challenge for the future–"
213,300,000 yen
- Japan Science and Technology Agency (JST)
CREST Project "Statistical Computational Cosmology with Big Astronomical Imaging Data"
41,800,000 yen
- Japan Aerospace Exploration Agency (JAXA)
"Development of polarization modulator for the LiteBIRD project"
51,000,000 yen
- Japan Society for the Promotion of Science (JSPS)
Core-to-Core Program "International Center for Observational Proof of Inflationary Universe"
15,840,000 yen

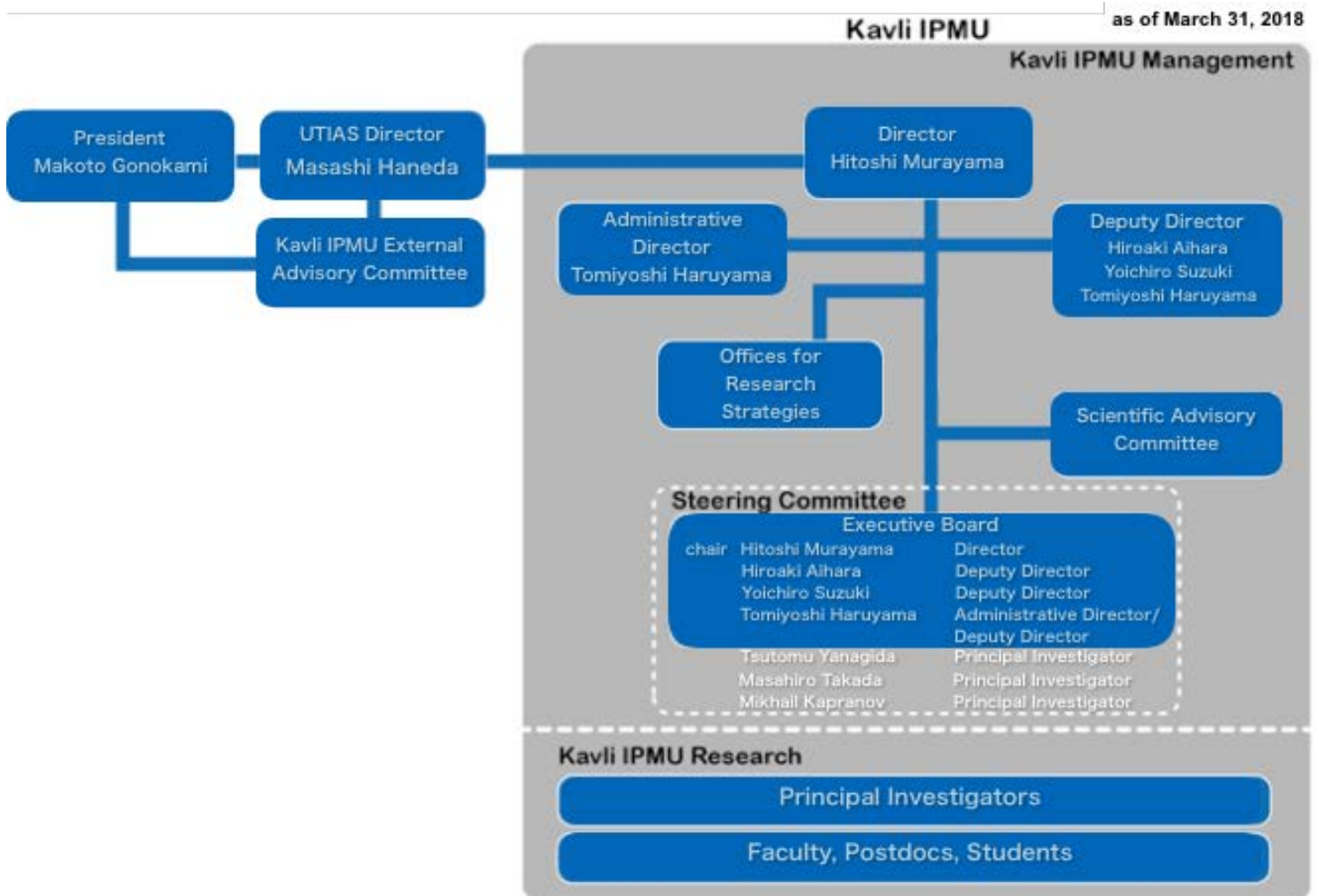
3. International research conferences or symposiums held to bring world's leading researchers together

- Indicate the number of international research conferences or symposiums held in FY2017 and give up to three examples of the most representative ones using the table below.

| FY 2017: 11 meetings | |
|--|--|
| Major examples (meeting titles and places held) | Number of participants |
| "Developments of mathematics at IPMU: in honor of Kyoji Saito" Lecture Hall, Kavli IPMU | From domestic institutions: 79 From overseas institutions: 15 |
| "5th Hyper-Kamiokande Proto-Collaboration Meeting" Lecture Hall, Kavli IPMU | From domestic institutions: 55 From overseas institutions: 42 |
| "9th PFS general collaboration meeting" Lecture Hall, Kavli IPMU | From domestic institutions: 57 From overseas institutions: 79 |

4. Center's management system

- Please diagram management system in an easily understood manner.
- If any changes have been made in the management system from that in the latest "center project," please describe them. Please describe any important changes made in such as the center director, administrative director, head of host institution, and officer(s) in charge at the host institution (e.g., executive vice president for research).



5. Campus Map

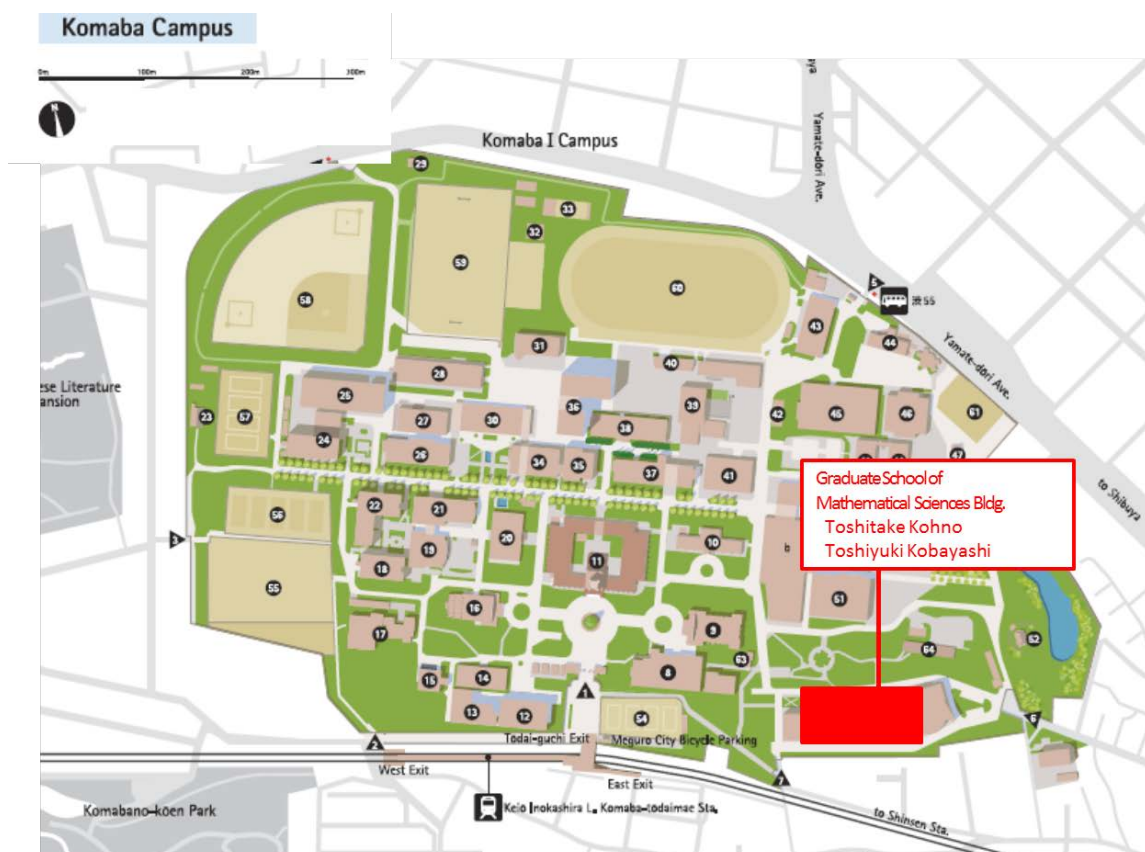
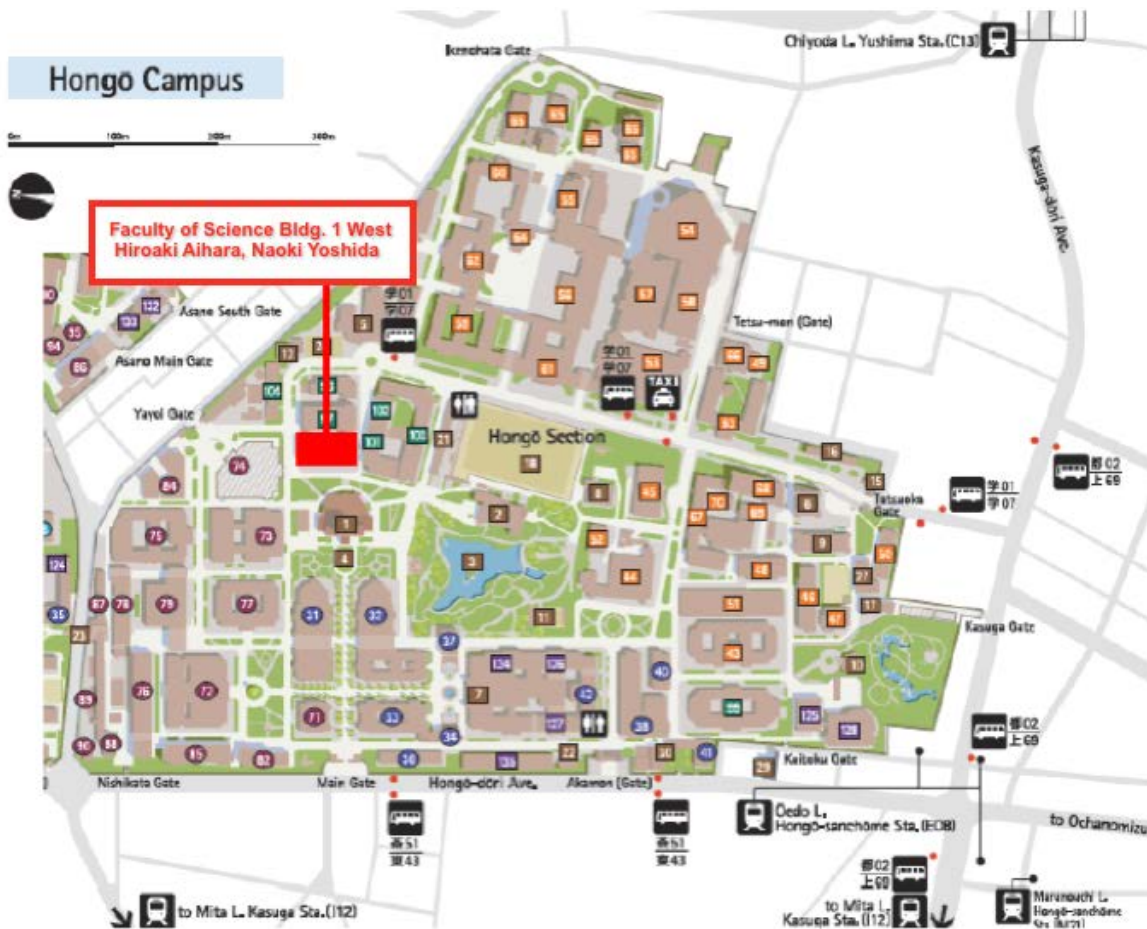
- Please draw a simple map of the campus showing where the main office and principle investigator(s) are located.

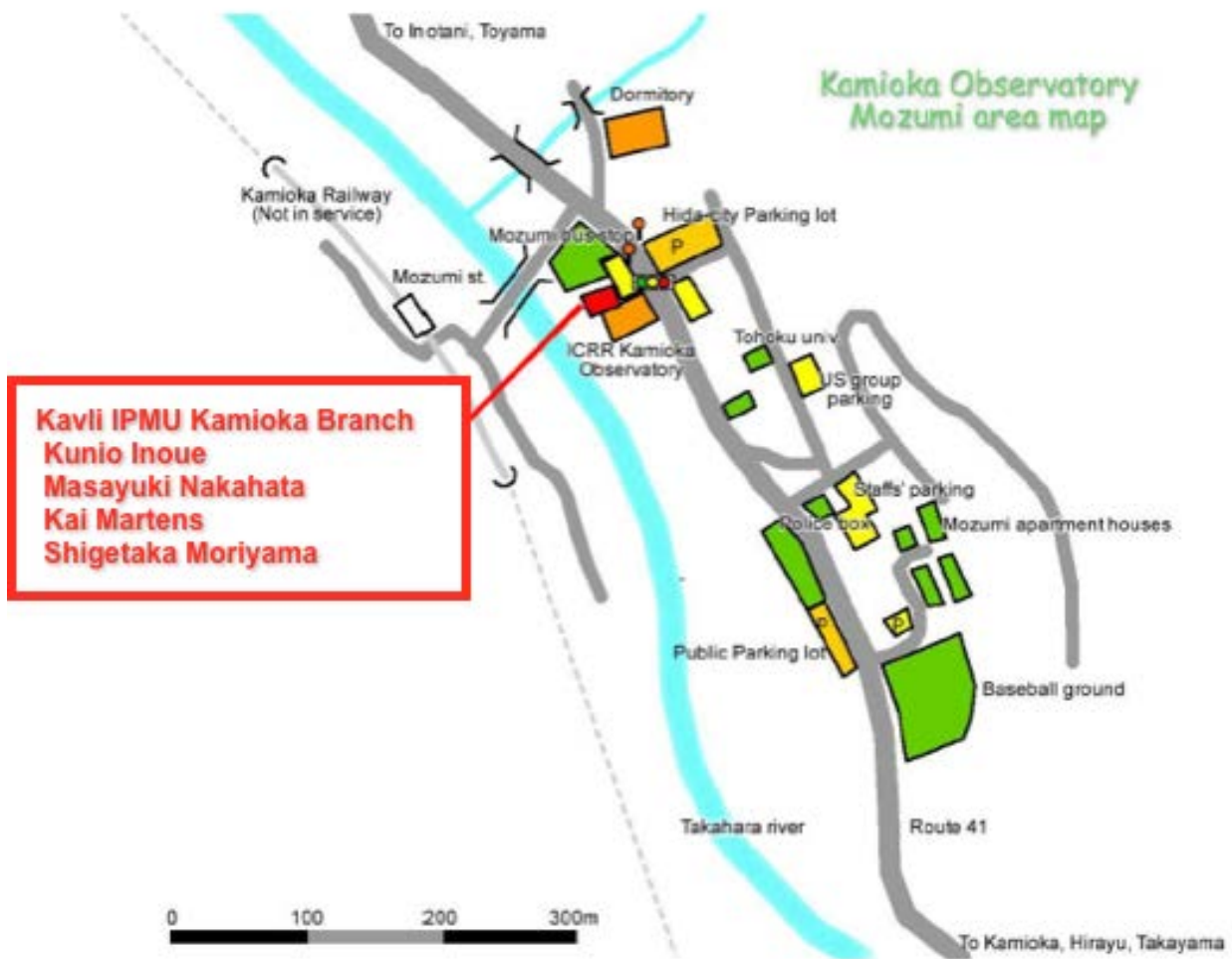


Kashiwa Campus

0m 100m 200m 300m







Appendix 3-1a FY 2017 Records of Center Activities

1. Researchers and other center staffs, satellites, partner institutio

1-1. Number of researchers and other center staffs

* Please fill in the number of researchers and other center staffs in the table blow.

* Please describe the final goals for achieving these numbers and dates when they will be achieved.

a) Principal Investigators (full professors, associate professors or other researchers of comparable standing)

(persons)

| | At beginning of project | At end of FY 2017 | Final goal (Date: 4, 2022) |
|--|-------------------------|-------------------|-------------------------------|
| Researches from within the host institution | 10 | 16 | 11 |
| Foreign researchers invited from abroad | 5 | 7 | 8 |
| Researchers invited from other Japanese institutions | 3 | 3 | 3 |
| Total principal investigators | 18 | 26 | 22 |

b) Total members

| | At beginning of project | | At end of FY2017 | | Final goal (Date: 4, 2022) | |
|---|-------------------------|----|-------------------|----|-------------------------------|----|
| | Number of persons | % | Number of persons | % | Number of persons | % |
| Researchers | 18 | / | 274 | / | 213 | / |
| Overseas researchers | 5 | 28 | 111 | 41 | 83 | 39 |
| Female researchers | 0 | 0 | 22 | 8 | 5 | 2 |
| Principal investigators | 18 | / | 26 | / | 22 | / |
| Overseas PIs | 5 | 28 | 7 | 27 | 8 | 36 |
| Female PIs | 0 | 0 | 2 | 8 | 1 | 5 |
| Other researchers | 0 | / | 248 | / | 191 | / |
| Overseas researchers | 0 | 0 | 104 | 42 | 75 | 39 |
| Female researchers | 0 | 0 | 20 | 8 | 4 | 2 |
| Research support staffs | 0 | / | 27 | / | 28 | / |
| Administrative staffs | 3 | / | 10 | / | 10 | / |
| Total number of people who form the "core" of the research center | 21 | / | 311 | / | 251 | / |

Appendix 3-2 Project Expenditures

1) Overall project funding

* In the "Total Cost" column, enter the total amount of funding required to implement the project, without dividing it into funding sources.

* In the "Amount covered by WPI funding" column, enter the amount covered by WPI within the total amount.

* In the "Personnel," "Project activities," "Travel," and "Equipment" blocks, the items and details may be changed to coincide with the project's actual content.

| (Million yens) | | | | Costs (Million yens) | |
|--|---|-------------|-------------------------------------|--|-------------|
| Cost Items | Details (For Personnel - Equipment please fill in the breakdown of fiscal expenditure, and the income breakdown for Research projects.) | Total Costs | Amount covered by WPI funding | | |
| | | | | WPI grant in FY 2017 | 1046 |
| Personnel | Center director and Administrative director | 36 | 36 | | |
| | Principal investigators (no. of persons):11 | 113 | 0 | Costs of establishing and maintaining facilities | 0 |
| | Other researchers (no. of persons):98 | 598 | 340 | Establishing new facilities (Number of facilities: , OO m ²) | 0 |
| | Research support staffs (no. of persons):28 | 100 | 98 | Repairing facilities (Number of facilities: , OO m ²) | 0 |
| | Administrative staffs (no. of persons):10 | 78 | 78 | Others | 0 |
| | Subtotal | 925 | 552 | | |
| Project activities | Gratuities and honoraria paid to invited principal investigators (no. of persons):15 | 25 | 25 | Cost of equipment procured | 134 |
| | Cost of dispatching scientists (no. of persons):2 | 4 | 4 | Cryostat for testing radio telescope for cosmic background (Number of units:1) | 34 |
| | Research startup cost (no. of persons):52 | 28 | 28 | millimeter-wave network analyzer (Number of units:1) | 16 |
| | Cost of satellite organizations (no. of satellite organizations):1 | 38 | 38 | Others | 84 |
| | Cost of international symposiums (no. of symposiums):11 | 3 | 3 | | |
| | Rental fees for facilities | 5 | 5 | | |
| | Cost of consumables | 82 | 58 | | |
| | Cost of utilities | 36 | 28 | | |
| Other costs | 187 | 88 | | | |
| | Subtotal | 408 | 277 | | |
| Travel | Domestic travel costs | 15 | 15 | | |
| | Overseas travel costs | 41 | 39 | | |
| | Travel and accommodations cost for invited scientists (no. of domestic scientists):42 (no. of overseas scientists):270 | 45 | 45 | | |
| | Travel cost for scientists on secondment (no. of domestic scientists):6 (no. of overseas scientists):9 | 3 | 3 | | |
| | Subtotal | 104 | 102 | | |
| Equipment | Depreciation of buildings | 109 | 0 | | |
| | Depreciation of equipment | 186 | 68 | | |
| | Subtotal | 295 | 68 | | |
| Research projects (Detail items must be fixed) | Projects supported by other government subsidies, etc. | 767 | 0 | | |
| | Grants-in-Aid for Scientific Research, etc. | 242 | 0 | | |
| | Commissioned research projects, etc. | 67 | 0 | | |
| | Joint research projects | 60 | 0 | | |
| | Others (donations, etc.) | 123 | 0 | | |
| | Subtotal | 1259 | 0 | | |
| | Total | 2991 | 999 | | |

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Kavli IPMU
Appendix 3-2

2) Costs of Satellites and Partner institutions

| (Million yens) | | | |
|--------------------|--|-------------|--------------------------|
| Cost Items | Details | Total Costs | Amount covered by WPI |
| Personnel | Principal investigators (no. of persons):0 | 35.7 | 35.7 |
| | Other researchers (no. of persons):6 | | |
| | Research support staffs (no. of persons):0 | | |
| | Administrative staffs (no. of persons):0 | | |
| | Subtotal | 35.7 | 35.7 |
| Project activities | Subtotal | 1.8 | 1.8 |
| Travel | Subtotal | 0.5 | 0.5 |
| Equipment | Subtotal | 0 | 0 |
| Research projects | Subtotal | 0 | 0 |
| | Total | 38 | 38 |

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Appendix 4 FY 2017 Status of Collaboration with Overseas Satellites

1. Coauthored Papers

- List the refereed papers published in FY 2017 that were coauthored between the center's researcher(s) in domestic institution(s) (include satellite institutions) and overseas satellite institution(s). List them by overseas satellite institution in the below blocks.
- Transcribe data in same format as in Appendix 1. Italicize the names of authors affiliated with overseas satellite institutions.
- For reference write the Appendix 1 item number in parentheses after the item number in the blocks below. Let it free, if the paper is published in between Jan.-Mar. 2018 and not described in Appendix 1.

Overseas Satellite 1 Berkeley (Total: 4 papers)

1) (59) A Measurement of the Cosmic Microwave Background B-mode Polarization Power Spectrum at Subdegree Scales from Two Years of POLARBEAR Data

Ade, PAR et al. (including *Lee, A. T.*)

ASTROPHYSICAL JOURNAL 848(2), 121, OCT 20 2017

2) (182) Performance of a continuously rotating half-wave plate on the POLARBEAR telescope

Takakura, S et al. (including *Lee, A. T.*)

JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (5), 8, MAY 2017

3) (201) Making maps of cosmic microwave background polarization for B-mode studies: the POLARBEAR example

Poletti, D et al. (including *Lee, A. T.*)

ASTRONOMY & ASTROPHYSICS 600, A60, APR 2017

4) Pure natural inflation

Nomura, Y; Watari, T; Yamazaki M

Physics Letters B776, 227, JAN 10 2018

2. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY 2017. Enter by institution and length of exchange.
- Write the number of principal investigator visits in the top of each space and the number of other researchers in the bottom.

Overseas Satellite 1:

<To satellite>

| | Under 1 week | From 1 week to 1 month | From 1 month to 3 months | 3 months or longer | Total |
|--------|--------------|------------------------|--------------------------|--------------------|-------|
| FY2017 | 5 | 8 | 1 | 0 | 14 |
| | 4 | 12 | 0 | 0 | 16 |

<From satellite>

| | Under 1 week | From 1 week to 1 month | From 1 month to 3 months | 3 months or longer | Total |
|--------|--------------|------------------------|--------------------------|--------------------|-------|
| FY2017 | 2 | 0 | 0 | 0 | 2 |
| | 13 | 16 | 0 | 0 | 29 |

Overseas Satellite 2:

<To satellite>

| | Under 1 week | From 1 week to 1 month | From 1 month to 3 months | 3 months or longer | Total |
|--------|--------------|------------------------|--------------------------|--------------------|-------|
| FY2017 | | | | | |
| | | | | | |

<From satellite>

| | Under 1 week | From 1 week to 1 month | From 1 month to 3 months | 3 months or longer | Total |
|--------|--------------|------------------------|--------------------------|--------------------|-------|
| FY2017 | | | | | |
| | | | | | |

Appendix 5 FY 2017 Visit Records of World Top World-level Researchers from Abroad

* If top world-level researchers have visited/ stayed at the Center, please provide information on them in the below table.

* To determine whether the researcher is a "top world-level researcher," please see the standard stipulated in the Application Guideline.

Total: 22

| | Name | Age | Affiliation (Position title, department, organization) | Academic degree, specialty | Record of research activities (Awards record, etc.) | Time, duration | Summary of activities during stay at center (e.g., participation as principal investigator; short-term stay for joint research; participation in symposium) |
|---|-----------------------|-----|--|-------------------------------|---|--------------------------|--|
| 1 | Joseph Silk | 75 | Homewood Professor, Dept. of Physics & Astronomy Johns Hopkins University | PhD. Astronomy | Royal Society Bakerian Medal (2007) Balzan Prize (2011) | 2018/3/4– 2018/3/6 | Short-term stay for joint research |
| 2 | Kevin S. McFarland | | Professor of Physics, Dept. of Physics and Astronomy University of Rochester | PhD. Physics | Alfred P. Sloan Research Fellow (1998) Department of Energy Outstanding Junior Investigator (1999) Cottrell Scholar (2001) National Science Foundation CAREER award (2002) Fellow of the American Physical Society (2005) Breakthrough Prize in Fundamental Physics (2015) | 2018/1/16 | Special Seminar Speaker |
| 3 | James Edward Gunn | 79 | Emeritus professor, Princeton University | | Catherine Wolfe Bruce gold medal (2013) Gruber Prize in Cosmology(2005), Swedish Academy of Science's Crafoord Prize (2005) Gold Medal of the Royal Astronomical Society (1994) American Astronomical Society's highest honor (2002) Henry Norris Russell Lectureship (2005) | 2017/11/27– 2017/12/1 | Participation in the 9th PFS general collaboration meeting |
| 4 | Timothy Heckman | 66 | Dr. A. Hermann Pfund Professor and Department Chair, Dept. of Physics & Astronomy Johns Hopkins University | Ph. D. Astrophysics | Elected as a Fellow of the American Academy of Arts & Sciences (2013) Named by Thomas Reuters as a one of "The World's Most Influential Scientific Minds" and a "Highly Cited Researcher" (2013–15) Named Overseas Fellow of Churchill College, Cambridge University (2015) Named Sackler Distinguished Visitor at Cambridge University (2015) Named "Highly Cited Researcher" by Web of Universities (2016) Elected as Member of the National Academy of Sciences (2016) | 2017/11/27– 2017/12/1 | Participation in the 9th PFS general collaboration meeting |

| | | | | | | | |
|----|--------------------|----|---|--|---|-------------------------------|---|
| 5 | Edourd Brezin | 79 | Emeritus professor, LPTENS | Ph.D. Physics | Dirac Medal of the International Centre for Theoretical Physics (2011) French Academy of Sciences (1991) foreign associate of the United States National Academy of Sciences (since 2003) Foreign member of the Royal Society (since 2006) | 2017/11/9 | Special Seminar Speaker |
| 6 | Christopher Walter | | Professor, Physics dept., Duke University | Ph.D. | Fellow of the American Physical Society (2017) Breakthrough Prize in Fundamental Physics. Breakthrough Prize (2016) NSF Career Award. National Science Foundation (2009) | 2017/11/6-9, 2017/5/20-6/4 | Short-term stay for joint research |
| 7 | Bryan Webber | 74 | Emeritus Professor, Dept. of Physics, University of Cambridge | PhD. Experimental Particle Physics | Institute of Physics Dirac Medal for Theoretical Physics (2008) American Physical Society J.J.Sakurai Prize for Theoretical Particle Physics (2012) | 2017/11/6-18, 2017/4/17-28 | Short-term stay for joint research |
| 8 | Richard Ellis | 67 | Principal Investigator Department of Physics and Astronomy University College London | Ph. D. Astrophysics | Royal Astronomical Society Group Award (2008) Gold Medal, Royal Astronomical Society (2011) Breakthrough Prize in Fundamental Physics (2014) Carl Sagan Memorial Award (2017) | 2017/10/16- 2017/10/18 | Symposium Speaker (Kavli IPMU 10th Anniversary) |
| 9 | Andrei Okounkov | 48 | Aamuel Eilenberg Professor of Mathematics, Mathematics Dept. Columbia University | PhD. Mathematics | European Mathematical Society Prize (2004) Fields Medal (2006) National Academy of Science (2012) | 2017/10/15- 2017/10/19 | Symposium Speaker (Kavli IPMU 10th Anniversary) |
| 10 | David J. Gross | 77 | Director Kavli Institute for Theoretical Physics, University of California, Santa Barbara | Ph.D. Physics | Nobel Prize in Physics (2004) High Energy and Particle Physics Prize, European Physical Society (2003) Grande Médaille D' or de l' Académie des Science, France (2004) Recipient Golden Plate Award, Academy of Achievement (2005) San Carlos Boromero Award, University of San Carlos, Philippines (2008) Richard E. Prange Prize , University of Maryland (2013) Medal of Honor of the Joint Institute for Nuclear Research, Dubna, Russia (2016) | 2017/10/15- 2017/10/17 | Participation in the 5th Hyper-Kamiokande Proto-Collaboration Meeting |

| | | | | | | | |
|----|-------------------|----|--|------------------------|---|---------------------------|--|
| 11 | David R. Morrison | 62 | Distinguished Professor of Mathematics and Physics, Dept. of Mathematics and Physics Univ. of California, Santa Barbara | Ph.D. Mathematics | Mathematical Sciences Research Institute Research Professorship (2006) Fellow of the American Mathematical Society (2013) Fellow of the American Physical Society (2014) Elected to the American Academy of Arts and Sciences (2015) | 2017/10/15– 2017/10/22 | Participation in the Kavli IPMU 10th Anniversary Symposium |
| 12 | John Ellis | 71 | Clerk Maxwell Professor of Theoretical Physics, Dept. of Physics King's College in London | PhD. | Maxwell Medal (1982) Paul Dirac Prize (2005) Fellow of the Royal Society of London (1985) Honorary Fellow of King's College Cambridge and of King's College London (1991) | 2017/10/15– 2017/10/19 | Participation in External Advisory Committee |
| 13 | Nigel Smith | | Director, SNOLAB | Ph. D. Astrophysics | Member of Canadian Institute of Particle Physics, Professional Physicist(2009, 2015) Member of Canadian Association of Physics (2009) Science and Engineering Ambassador (STEMNET) (2008) Member of the International Astronomical Union, and COSPAR (2006) Fellow of the Royal Astronomical Society (1995) Member of the Institute of Physics, Chartered Physicist (1993) US Congressional medal and winter-over bar for Antarctic duties (1988) | 2017/10/15– 2017/10/18 | Participation in External Advisory Committee |
| 14 | Shing-Tung Yau | 68 | William Gaspar Graustein Professor of Mathematics Department of Physics, Harvard University | PhD in Mathematics | 2003 International Scientific and Technological Cooperation Award National Medal Of Science, USA (1997) Crafoord Prize, The Royal Swedish Academy of Science (1994) Humboldt Research Award, The Alexander von Humboldt Foundation, Germany (1991) Fields Medal, International Congress of Mathematicians (1982) | 2017/10/15– 2017/10/18 | Symposium Speaker (Kavli IPMU 10th Anniversary) |
| 15 | Steven Kahn | 63 | Professor, Physics Dept, Stanford University Stanford Linear Accelerator Center | PhD. Physics | Elected to Fellowship, American Physical Society (1991) Member, American Academy of Arts and Sciences (AAAS), (2012) | 2017/10/15– 2017/10/19 | Symposium Speaker (Kavli IPMU 10th Anniversary) |

| | | | | | | | |
|----|------------------------|----|---|---------------------|---|-------------------------|--|
| 16 | Norbert Langer | 59 | Group Head, Stellar Physics Group, Argelander Institute for Astronomy, University of Bonn | PhD | the Alexander von Humboldt Professorship (2018) German Astronomical Society's Ludwig Biermann Award (1986) | 2017/9/16– 2017/9/30 | Workshop Speaker (Workshop on Stellar Evolution, Supernova Nucleosynthesis Across Cosmic Time) |
| 17 | Michel Gonin | | Director Laboratoire Leprince- Ringuet | | de chevalier de la Légion d'honneur (2017) | 2017/9/6– 2017/9/9 | Participation in the 5th Hyper- Kamiokande Proto-Collaboration Meeting |
| 18 | Nicholas Kaiser | 63 | Professor, Institute for Astronomy University of Hawaii at Mānoa | Ph.D. Astronomy | Gold medal in astronomy by the Royal Astronomical Society (RAS) (2017) Ontario Fellow of the CIAR Cosmology Program (1988) Helen Warner Prize of the American Astronomical Society (1989) NSERC Steacie Fellowship (1991–92) Herzberg Medal of the Canadian Association of Physicists (1993) Rutherford Medal of the Royal Society of Canada (1997) | 2017/9/4– 2017/9/12 | Colloquium Speaker |
| 19 | Elena Aprile | 64 | Professor, Physics Dept, Columbia University | Ph.D. Physics | Weizmann Institute of Science, Rosi and Max Varon Visiting Professorship (2012) Ufficiale, Repubblica Italiana (2005) Fellow, American Physical Society (2001) National Science Foundation Career Award (1991) | 2017/7/17 | Seminar Speaker |
| 20 | Edward T. Kearns | | Professor, Dept. of Physics, Boston University | Ph.D. Physics | Fellow, American Physical Society (2007) Universities Research Association (URA) Fellow (2013) Intensity Frontier Fellow (2013) Breakthrough Prize in Fundamental Physics (2015) | 2017/6/17– 2017/6/26 | Short-term stay for joint research |
| 21 | Barry Barish | 82 | Ronald and Maxine Linde Professor of Physics, Emeritus, Caltech | Ph.D. Physics | The Nobel Prize in Physics (2017) Henry Draper Medal (2017) The Giuseppe and Vanna Cocconi Prize (2017) The Prince of Asturias Awards (2017) Fudan-Zhongzhi Science Award (2017) Enrico Fermi Prize (2016) American Ingenuity Award (2016) Klopsteg Memorial Award (2002) | 2017/5/28– 2017/6/1 | Colloquium Speaker |
| 22 | Alexander Varchenko | 69 | Ernest Eliel Professor, Dep. of Mathematics Univ. of North Carolina at Chapel Hill | PhD. Mathematics | Book Fellow of the Clay Mathematics Institute (2002) Chaires d'Excellence Pierre de Fermat (2008) Simons Fellow in Mathematics (2015) Moscow Mathematical Society Award (1973) | 2017/4/24– 2017/4/29 | Workshop Speaker (workshop on Developments of mathematics at IPMU: in honor of Kyoji Saito) |

Appendix 6 FY2017 State of Outreach Activities

* Using the table below, show the achievements of the Center's outreach activities in FY2017(number of activities, times held).

* Describe those activities that have yielded novel results or that warrant special mention in the "Special Achievements" space below.

* In appendix 7, list and describe media coverage (e.g., articles published, programs aired) in FY2017 resulting from press releases and reporting.

| Activities | FY2017 (number of activities, times held) |
|--|---|
| PR brochure, pamphlet | 16 |
| Lectures, seminars for general public | 14 |
| Teaching, experiments, training for elementary, secondary and high school students | 3 |
| Science café | 7 |
| Open houses | 1 |
| Participating, exhibiting in events | 4 |
| Press releases | 21 |

<Special Achievements>

New material developed to target new audiences

A convergence of Science and Art

Developing educational material on dark matter for high school students

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Kavli IPMU

Social Network Service (SNS) Usage

- Facebook

- Kavli IPMU (account name: KavliIPMU):<http://www.facebook.com/KavliIPMU> (since September 2009)

A total of 74 Facebook posts were published on the Kavli IPMU page. More than 80 per cent of posts received more than 1000 likes.

The most popular post was about Director Hitoshi Murayama being chosen as one of the 100 influencers in the world by the Einstein Legacy Project, which was read 13,056 times and received 376 likes.

- Hitoshi Murayama (account name: Hitoshi Murayama-Kavli IPMU):

<http://www.facebook.com/pages/Hitoshi-Murayama-Kavli-IPMU/289807884480621> (since February 2013)

- Twitter

- Hiroshi Ooguri (account name: PlanckScale), since September 2009

- Hitoshi Murayama (account name: sleptogenesis), since January 2010

- Blogs

- Hiroshi Ooguri: <http://planck.exblog.jp/> (since January 2009)

General public books published in FY 2017:

- "An Introduction to the Multiverse: Why do we exist in this Universe (マルチバース宇宙論入門 私たちはなぜ〈この宇宙〉にいるのか)" by Yasunori Nomura

Published in July 2017, Seikaisha Inc.

Other best sellers

- "What is the Universe Made Of? (宇宙は何でできているのか)" by Hitoshi Murayama

Published September 2010, Gentosha Inc.

331,000 copies published

- "What is Gravity? (重力とは何か?)" by Hiroshi Ooguri

Published May 2012, Gentosha Inc.,

140,700 copies published

- "Is There Really Only One Universe (宇宙は本当にひとつなのか)" by Hitoshi Murayama

Published July 2011, Kodansha Inc.

111,700 copies published

- "Why Do We Exist (宇宙になぜ我々が存在するのか)" by Hitoshi Murayama

Published January 2013, Kodansha Inc.,

71,300 copies published

- "Introduction to Superstring Theory (大栗先生の超弦理論入門 九次元世界にあった究極の理論)** by Hiroshi Ooguri

Published August 2013, Kodansha Inc.,

44,000 copies published

* This book received the 30th Kodansha Science Publication Award in September 2014.

- "How is the Universe this Complete (宇宙はなぜこんなにうまくできているのか)" by Hitoshi Murayama

Published January 2012, Shueisha Inc.

29,000 copies published

- "Strong Forces and Weak Forces: Unlocking the Magic that the Higgs Particle has Cast on the Universe (強い力と弱い力～ヒッグス粒子が宇宙にかけた魔法を解く～)" by Hiroshi Ooguri

Published January 2013, Gentosha Inc.,

23,000 copies published

- "The Experiment that Made the Universe (宇宙を創る実験)" by Hitoshi Murayama

Published on December 2014, Shueisha Inc.

15,000 copies published

- "The World As Seen In The Language of Mathematics (数学の言葉で世界を見たら 父から娘に贈る数学)" by Hiroshi Ooguri

Published on March 2015, Gentosha Inc.

14,000 copies published

* This book was translated into Mandarin (simplified Chinese characters) in May 2017, Korean in June 2017, and Mandarin (traditional Chinese characters) in September 2017.

- "The Search for Truth (真理の探究 仏教と宇宙物理学の対話)" by Hiroshi Ooguri and Shizuka Sasaki

Published in November 2016, Gentosha Inc.

11,000 copies published

Appendix 7 FY 2017 List of Project's Media Coverage

* List and describe media coverage (e.g., articles published, programs aired) in FY2017 resulting from press releases and reporting.

| | Date | Types of Media (e.g., newspaper, television) | Description |
|----|--------------------------|---|--|
| 1 | 21/04/2017 | Asahi Shimbun (Kanagawa region, newspaper) | "Youth Scroll - Memories from Toko Gakuen" * Features a profile of Toko Gakuen graduate and Kavli IPMU Project Associate Professor Tomotake Matsumura |
| 2 | 25/04/2017 | Nikkei Science (science magazine) | "Feature: What we know so far about inflation theory" * Commentary by Kavli IPMU PI Eiichiro Komatsu |
| 3 | 23/05/2017 | Scientific American (science magazine) | "The Quantum Multiverse" * Written by Kavli IPMU PI Yasunori Nomura |
| 4 | 01/06/2017 | Bioengineer.org, Scienmag and others (websites) | "Hitoshi Murayama named one of the 100 influencers in the world" * Article about Kavli IPMU Director Hitoshi Murayama being included in the 'Genius: 100 Visions of the Future' project by the Einstein Legacy Project. |
| 5 | 13/07/2017 | Cosmic Front NEXT (NHK BS TV) | "Was the Universe a coincidence? A necessity? The new chapter in cosmology" * Features Kavli IPMU PI Yasunori Nomura, PI Eiichiro Komatsu, Project Professor Masashi Hazumi, and Visiting Senior Scientist Katsuhiko Sato |
| 6 | 04/08/2017 | Mainichi Shimbun, Chunichi Shimbun and others (newspaper) | "Neutrino research project raises confidence level to 95% regarding CP violation" * Article about the T2K project involving Kavli IPMU Project Assistant Professor Mark Hartz, and features a comment from Kavli IPMU Director Hitoshi Murayama. |
| 7 | 03/08/2017 10/08/2017 | Cosmic Front NEXT (NHK BS TV) | "Hitoshi Murayama's Great Adventures in the Universe: The Beginning of the Universe", "Hitoshi Murayama's Great Adventures in the Universe: When will the Universe End?" was hosted by Kavli IPMU Director Hitoshi Murayama. Both shows were re-runs (the show originally aired on 09/02/2018 and 16/02/2018 respectively). The shows are a special extended, two-part documentary of the 2016 TV Documentary "Hitoshi Murayama's Great Adventures in the Universe" which received the 2017 Science Show Takayanagi Prize. |
| 8 | 07/08/2017 22/08/2017 | IFL Science, Madrimasd and others (websites) | "Neutrinos Continue To Show A Preference For Matter And This Has Big Consequences" * Research article about the T2K project, which involves Kavli IPMU Project Assistant Professor Mark Hartz. |
| 9 | 20/08/2017 | Heart of Time (NHK Educational TV) | "Heart of Time: Yogachara. Episode 5: Science of Yogachara" is a TV show with a guest appearance by Kavli IPMU PI Hiroshi 「こころの時代シリーズ 唯識に生きる -第5回 唯識の科学性-」 * Guest appearance by Kavli IPMU PI Hiroshi Ooguri. A conversation with Rikkyo University Emeritus Professor Koitsu Yokoyama at Kavli IPMU. |
| 10 | 01/09/2017 | Nikkei Science (science magazine) | "Feature: Multiverse and other worlds. The connection between inflation theory and quantum mechanics" * Commentary by Kavli IPMU PI Yasunori Nomura |
| 11 | 07/09/2017 | MyNavi News, excite news and others (websites) | "Ultraviolet light from superluminous supernova key to revealing explosion mechanism" * Japanese article about paper published by Kavli IPMU Project Researcher Alexey Tolstov, Senior Scientist Ken'ichi Nomoto et al. |
| 12 | 07/09/2017 08/09/2017 | Sci Fi Generation TV, AstroNews.ru and others (websites) | "Ultraviolet light from superluminous supernova key to revealing explosion mechanism" * English article about paper published by Kavli IPMU Project Researcher Alexey Tolstov, Senior Scientist Ken'ichi Nomoto et al. |
| 13 | 28/09/2017 29/09/2017 | Phys.org, Yahoo! News Canada and others (websites) | "Supersonic gas streams left over from the Big Bang drive massive black hole formation" * Article about paper published by Kavli IPMU PI Naoki Yoshida |

| | Date | Types of Media (e.g., newspaper, television) | Description |
|----|--------------------------|--|--|
| 14 | 06/10/2017 | International Business Times, Science Newsline and others (websites) | "Supernova Explosions Of Some White Dwarf Stars Triggered By Excessive Helium" * Article about paper including Kavli IPMU Senior Scientist Ken'ichi Nomoto, Professor Naoki Yasuda, and Project Assistant Professor Nao Suzuki, and lead by Senior Scientist Mamoru Doi |
| 15 | 04/11/2017 | Chunichi Shimbun (Gifu region, newspaper) | "Plans for Hyper-Kamiokande move forward as University of Tokyo establishes new institute" * Japanese article about the establishment of the Next-generation Neutrino Science Organization |
| 16 | 07/11/2017 | Physics World | 「A decade of success」 * Interview with Kavli IPMU Director Hitoshi Murayama, introduction to the Kavli IPMU |
| 17 | 10/11/2017 21/11/2017 | Physics World, Asian Scientist (website) | "Japan pushes ahead for Hyper-Kamiokande neutrino detector" * English article about the establishment of the Next-generation Neutrino Science Organization |
| 18 | 11/11/2017 | Diamond Weekly (magazine) | "COSMOLOGY: Why news about the detection of gravitational waves from neutron stars was groundbreaking" * One of eight articles written by Kavli IPMU PI Hiroshi Ooguri in his regular column in FY2017 |
| 19 | 21/11/2017 | MyNavi News (website) | "Researchers find way to improve simulations of neutrinos and astrophysical plasma dynamics" * Article about paper by Kavli IPMU PI Naoki Yoshida et al. |
| 20 | 05/12/2017 | Daily Mail, Before It's News and others (websites) | "Do SIMPs hold the key to dark matter? Experts say 'strongly interacting massive particles' could finally unlock the mystery" * Article about Kavli IPMU Director Hitoshi Murayama's SIMP theory |
| 21 | 26/12/2017 | Newton (science magazine) | "The Higgs Particle and Resolving with Mystery of the Universe with the ILC" * Article introducing the ILC (International Linear Collider), commentary by Professor Hiromi Yokoyama et al. |
| 22 | 11/01/2018 | Cosmic Front MUSIC (NHK BS TV) | "Cosmic Front MUSIC" * guest appearance by Kavli IPMU Director Hitoshi Murayama |
| 23 | 29/01/2018 28/02/2018 | Chiba Nippo, Tokyo Shimbun and others (newspapers) | "Person of our Time = Kavli IPMU Director Hitoshi Murayama. 10 years since the establishment of the Kavli IPMU" * Interview with Kavli IPMU Director Hitoshi Murayama by Kyodo News in commemoration of the Kavli IPMU 10h Anniversary. This article was published in several regional newspapers through Kyodo News. |
| 24 | 22/02/2018 | Bright Surf, Before It's News and others (websites) | "Rare first moment of stellar explosion captured by amateur astronomer" * English article about paper by Kavli IPMU Visiting Associate Scientist Melina Bersten, Senior Scientist Ken'ichi Nomoto et al. |
| 25 | 22/02/2018 | MyNavi News, goo news and others (websites) | "Utokyo team analyze rare first moment of stellar explosion captured by amateur astronomer" * Japanese article about paper by Kavli IPMU Visiting Associate Scientist Melina Bersten, Senior Scientist Ken'ichi Nomoto et al. |
| 26 | 27/02/2018 03/03/2018 | Bijutsu Techo, Qetic (website) | "Where Science and Art meet at 're ⁿ '- Encounter between Science and Art 2018' on now! Work inspired by interactions with researchers" * Promotional article about the Kavli IPMU Artist in Residence art exhibition (March 9 - 25, 2018) |
| 27 | 28/02/2018 23/03/2018 | Yomiuri Shimbun, Nikkei Shimbun and others (newspapers) | "Science News: Was the galaxy made by dark matter? Researchers make detailed map" * Comment by Kavli IPMU Director Hitoshi Murayama. Additional interview by Nikkei Shimbun, which resulted in a dark matter feature article. |
| 28 | 26/03/2018 | Newton (science magazine) | "Episode 2: Mathematics in a Curved World. The curious geometry that opened the way to the theory of general relativity" * Commentary by Kavli IPMU PI Toshitake Kohno |
| 29 | 28/03/2018 | Nikkan Kogyo Shimbun (newspaper) | "Lasers: A new groundbreaking renovation" * Column article including comment by Kavli IPMU Director Hitoshi Murayama at the JAXA-Kavli IPMU Hard X-ray and Gamma ray Imaging Collaboration press conference |
| 30 | 28/03/2018 31/03/2018 | MyNavi News, Jiji Press (website) | "Using science about the universe to improve cancer research - a new collaboration between the Kavli IPMU and JAXA" * Articles about the JAXA-Kavli IPMU Hard X-ray and Gamma ray Imaging Collaboration |