

World Premier International Research Center Initiative (WPI) FY2016 WPI Project Progress Report (Post-10th Year Evaluation)

Host Institution	The University of Tokyo	Host Institution Head	Makoto Gonokami
Research Center	Kavli Institute for the Physics and Mathematics of the Universe	Center Director	Hitoshi Murayama

Common instructions:

* Unless otherwise specified, prepare this report from the timeline of 31 March 2017.

* So as to base this fiscal year's follow-up review on the document "Post-interim evaluation revised center project," please prepare this report from the perspective of the revised project.

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

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

Scientific research progress

In the calendar year (CY) 2016, 345 (450 when including WPI-related) papers were published. We have consistently produced a large number of scientific papers in the past 3 years (452 in CY2014, 466 in CY2015 including WPI-related papers) after a steady increase (75, 199, 240, 292, 347, 380 papers from CY2008 to CY2013). Among the WPI papers published in CY2016, the rate of highly cited papers "top 1% of papers" was 16 (3.6%) based on the Web of Science by Thomson Reuters. The impact factor for all of our refereed papers published from the institute's inception to Dec 2016 are as follows: the average number of citations per paper is 23.1; 85 papers have over 100 citations and 287 over 50 citations in which review papers are excluded. The fraction of CY2016 papers with international collaboration reaches 78 %. The Kavli IPMU members also received 10 valuable prizes/awards during FY2016. Highlights of our scientific results are summarized below.

- Theoretical physicists in the Kavli IPMU work on a variety of topics. The particle phenomenology group led by T. Yanagida and S. Matsumoto searched for new physics with the 750GeV diphoton anomaly reported by the LHC experiment in 2015. H. Murayama's proposal that dark matter is Strongly Interacting Massive Particle as "dark pions" has attracted a lot of attention, selected as one of Highly Cited Papers based on Thomson Reuters. Our new young professor Y. Tachikawa conducted research in various aspects of quantum field theories including time-reversal anomaly of 2+1 dimensional systems. String theorists performed various studies including that of new aspects of duality map between Heterotic and Type IIA string theories by T. Watari.
- Mathematicians actively work on a variety of subjects in arithmetic, algebraic complex and symplectic geometry and representation theory that have deep connections with theoretical physics in particular with string theory. M. Kapranov is a leader in higher category theory and significantly boosts our international reputation. T. Abe was awarded the 2017 Mathematical Society of Japan Spring Prize.
- The XMASS team led by Y. Suzuki looked for annual modulation of the dark matter signal using the data spanning more than a year. They found that almost all the DAMA/LIBRA allowed region in 6 to 16 GeV/c² are excluded when assuming WIMP dark matter.
- The T2K collaboration presented its first neutrino oscillation results using a simultaneous analysis of data collected with neutrino and antineutrino beam configurations. M. Hartz and C. Bronner led the analysis of T2K data to give the world's best constraint on the parameter related to CP violation in neutrino mixing. They found that their result is most consistent with a value of the parameter for which CP violation is large. The result has been accepted for publication in Physical Review Letters (PRL) with the "Editors' Suggestions" designation.
- The KamLAND-Zen led by K. Inoue and A. Kozlov demonstrated the best sensitivity in the search for neutrinoless double-beta decay in Xenon 136. The team set the best limit on the effective Majorana neutrino mass of 61 meV to 165 meV, which excludes most of the degenerate mass region. The work was published in PRL as an "Editors' Suggestions".
- Both the Super-Kamiokande and T2K Collaborations have now officially endorsed and approved the IPMU-originated and IPMU-developed idea of loading Super-K with gadolinium, a concept known as GADZOOKS! (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!). This new phase of operations, formally known as SK-Gd, is expected to get underway in 2018, with the first gadolinium load going into the tank in 2019.
- The CMB satellite mission, LiteBIRD, is now progressed to the JAXA/ISAS PhaseA1 and has also been selected as a top-priority large-scale project "Master plan 2017" by the Science Council of Japan. The LiteBIRD team extends the collaboration in different fields: the Ohsaki group at the

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

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

Interdisciplinary studies

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

Globalization

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

Organizational Reform

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

Others

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

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

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 starts, what it is made of, what its fate is, what its fundamental laws are, and why we exist in it. We proposed to address these questions from the synergistic perspectives of physics, mathematics, experimental physics, and astronomy. Below we describe the research progress in 2016 related to each question.

How did the Universe start?

POLARBEAR, LiteBIRD: The CMB group at the Kavli IPMU has now evolved into 8 staff members working on the simulation, analysis and experiment for POLARBEAR and LiteBIRD. D. Kaneko and A. Ducout joined the group to work on POLARBEAR and LiteBIRD, respectively. Also, T. Matsumura, who is the cold mission system manager of LiteBIRD, joined the group to lead the satellite mission LiteBIRD that will be launched in the mid-2020s. POLARBEAR at Atacama, Chile has been observing since 2012. More data has been accumulated since the first publication and the analysis is in progress. The deployment of POLARBEAR2 is scheduled in one-year time scale and the preparation is in progress. The satellite mission, LiteBIRD, has now progressed to the JAXA/ISAS PhaseA1. LiteBIRD was selected as a top-priority large-scale project “Master plan 2017” by the Science Council of Japan. Laboratory B at Kavli IPMU has been refurbished to accelerate the experimental efforts of POLARBEAR and LiteBIRD. Three new cryostats were installed, two for a superconducting detector testing at the 100 mK operational temperatures, and a 1m diameter 4K cryostat for cryogenic optical testing. A laser machining system was also installed to study optical properties at millimeter wave.

What is the Universe made of?

Dark Matter: Nature of dark matter is a common interest to both astronomers and particle physicists. H. Murayama’s proposal that dark matter is Strongly Interacting Massive Particle as “dark pions” has attracted a lot of attention, placed in the top 1% of the academic field of Physics based on a highly cited threshold for the field and publication year on Thomson Reuters. H. Murayama further studied its phenomenology and pointed out that it can be looked for by Belle II, an experimental effort at the Kavli IPMU. It is even possible to study the spectroscopy of dark vector resonances using monophoton signal (JHEP1605, 090, 2016, with Y. Hochberg and E. Kuflik).

Particle phenomenology: On the aspect of the particle phenomenological research at the Kavli IPMU, significant efforts have been paid in 2016 to the study of the so-called 750GeV diphoton anomaly, which was reported by the LHC experiment at the end of 2015. Many studies were done at the Kavli IPMU with thinking deeply about what kind of new physics could be behind the anomaly. For instance, C. Han, T. Yanagida and N. Yokozaki discussed additional vector-like fermions for the anomaly in the framework of the gaugino mediation of supersymmetry breaking (PRD93, 055025, 2016). C. Chiang, H. Fukuda, M. Ibe and T. Yanagida attempted to explain the anomaly by the dilaton, a radial mode corresponding to the axion, in the heavy QCD axion model (PRD93, 095016, 2016). C. Han, K. Ichikawa, S. Matsumoto, M. M. Nojiri and M. Takeuchi found that a non-relativistic bound state of a pair of new vector-like colored heavy particles could be responsible for the anomaly and discussed its phenomenological and cosmological aspects (JHEP1604, 159, 2016). Though the anomaly has unfortunately gone last fall, the above studies inspired new ideas on model-building and the development of new algorithms at collider experiments. One example is the study by H. Fukuda, M. Ibe and M. Nojiri with LHC experimentalist O. Jinnouchi, discussing how to distinguish between a diphoton event and a pair of collimated photon-jets resulting from the subsequent decays of the highly boosted light axion-like particle (to be published in PTEP).

XMASS: An annual modulation of the dark matter signal in the direct detection experiments is expected from the Earth's rotation around the Sun. Data spanning more than one year from November 2013 to March 2015 was used to look for the modulation. By assuming WIMP dark matter, their results have excluded almost all the DAMA/LIBRA allowed region in 6 to 16 GeV/c². A simple modulation analysis revealed a small negative amplitude, but not significant. They have demonstrated diversity in the XMASS program. They obtained the best lower limit on the two-neutrino double electron capture of ¹²⁴Xe and ¹²⁶Xe. Two-neutrino mode gives new reference for the calculation of nuclear matrix elements while the neutrino-less mode demonstrates the lepton number violation. The detectability of the supernova burst neutrinos through the coherent nuclear scattering was discussed and they have shown that as much as 104 events are expected for the supernova at the Betelgeuse distance with negligible background.

What is the fate of the Universe?

SuMIRe (HSC and PFS): SuMIRe (Subaru Measurement of Images and Redshifts) is a large-scale international survey project aimed at uncovering the origin and future of the universe. This project is led by H. Murayama as a core researcher (PI), the science group leader M. Takada, and project manager N. Tamura, both at the Kavli IPMU. It involves both physicists and astronomers from the Academia Sinica Institute for Astronomy and Astrophysics (ASIAA, Taiwan), Jet Propulsion Laboratory of NASA, California Institute of Technology, Princeton University, Johns Hopkins University, Laboratoire d'Astrophysique Marseille, Universidad São Paulo, the Laboratório Nacional de Astrofísica (LNA, Brazil), the Max Planck Institute for Astrophysics, and the PFS Chinese consortium.

The wide-field imaging camera Hyper Suprime-Cam (HSC), a new 900M-pixel digital camera for Subaru Telescope, is one of the two subprojects of SuMIRe. The HSC team started scientific operations in March 2014, using 300 nights on the Subaru telescope over 5 years until 2019 or 2020, which is the largest ever survey program for the Japanese community. The HSC project just reached a big milestone. The team publicly released HSC data from the first 1.7 years (61.5 nights of observations) — the HSC DR1. The limiting magnitudes, which refer to the depth of the observations, are 26.4, 26.6 and 27.3 mag in r-band (about 620 nm wavelength) respectively, allowing observation of some of the most distant galaxies in the Universe. The dataset already contains almost 100 million galaxies and stars. The total amount of data taken so far by the HSC survey, meanwhile, comprises 80 terabytes, which is comparable to the size of the US-based Sloan Digital Sky Survey that took over 10 years to establish. The HSC team is now working very hard to prepare a series of the first-year science papers.

We also have made progress in the other part of the SuMIRe project: the wide-field multi-object spectrograph, Prime Focus Spectrograph, aimed at making spectroscopic follow-up to HSC images. The fiber positioner "Cobra" has been in mass production since Jan 2016, and the positioners are continuously being delivered to Caltech. The next step will be to integrate these positioners into modules with the mechanical parts and electronics that are being manufactured in parallel. The PFS team had a successful "first light" of the spectrograph module where all the fibers were illuminated and the spectral images were delivered nicely to the detector in the "red" camera. Since then, more detailed image characterization works have been ongoing. The near-infrared detector was successfully read out, while the integration of the camera cryostat is ongoing. The development of fiber cable that optically links the Subaru prime focus to the spectrograph system is progressing, and now the ~50m-long part to be installed on the telescope structure is being prototyped for design and performance validation. The PFS team envisions that the team can start scientific operations in 2020, spending more than 300 nights on the Subaru Telescope. The combination of HSC and PFS is unique 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 and Andromeda Galaxy.

The team, led by Tohoku University and Kavli IPMU member (M. Ishigaki, H. Murayama, M. Takada), discovered the record-breaking faint satellite galaxy of the Milky Way. The combination of the large aperture and the field of view of Hyper-Suprime Cam enabled this discovery. Their result suggests the presence of a large number of undetected dwarf satellites in the Milky Way halo, and provides important insights into galaxy formation.

Dark Energy and Expansion of the Universe The group led by T. Okumura, C. Hikage, T. Totani made a 3D map of 3000 galaxies 13 billion light years away and found that Einstein's general theory of relativity is still valid. This is the gravity test from the deepest galaxy map ever done. The result was press released by five institutions simultaneously and covered by more than 100 media outlets. An international team of astronomers including A. Sonnenfeld utilized time delay events among strong-lensed images of galaxies to measure the present expansion rate of the Universe, i.e., Hubble constant. They found that the measured expansion rate is faster than the expectation from the CMB measurements by ESA Planck satellite. The series of the papers was published in the Monthly Notices of the Royal Astronomical Society.

What are its fundamental laws?

Quantum Field Theory: Y. Tachikawa conducted research into various aspects of quantum field theories. First, in collaboration with K. Yonekura, a postdoc at the Kavli IPMU, he wrote three papers on the time-reversal anomaly of 2+1 dimensional systems. This is a hot topic in condensed matter physics in the last several years, and Tachikawa's aim in this series of works is to utilize the technique developed in high-energy physics to shed different light on this problem. As an example, in one paper, the duality of supersymmetric gauge theory was used to deduce the so-called collapse of the free classification by interaction of topological superconductors. Second, in collaboration with Y. Hatsuda and H. Katsura, he pointed out in a paper a mathematical relationship between the study of topological strings and the phenomenon called Hofstadter's butterfly in condensed matter physics. Third, in collaboration with his student H. Shimizu, he continued his study from the last few years on the six-dimensional superconformal field theories, and wrote a paper describing properties of string-like excitations in them.

String Theory: T. Watari uncovered new aspects of duality map between Heterotic and Type IIA string theories. Degenerating K3 fibre of Kulikov Type II and Type III in Type IIA description turns out to be soliton configurations in Heterotic string. Another method of determining the duality dictionary known to work for a few limited cases has been generalized to cover a much broader range of examples. The other paper proves that string compactifications on geometry with a given topology almost always contain vacua that have just three generations of quarks and leptons. This means the number of generations in the Standard Model is not useful information in pinning down the geometry for compactifications. It also points out that the results of Brill-Noether theory should apply to the number of vector-like pair particles that remain in low-energy spectrum. Various checks have been run to see that the constraints from the Brill-Noether theory are satisfied indeed in the examples where the low-energy spectrum has been computed.

Mathematics: M. Kapranov, with V. Schechtman, has given a description of the category of perverse sheaves on a Riemann surface in terms of the spanning graphs (arXiv:1601.01789). M. Kapranov, with G. Faonte and B. Hennion, has found higher-dimensional "derived" generalizations of the Kac-Moody Lie algebras, and shown that they act on rigidified derived moduli spaces of G-bundles on higher-dimensional manifolds (arXiv:1701.01368). With E. Routis, M. Kapranov further constructed the variety of complete complexes, which is a smooth normal crossing compactification of the variety of complexes and generalizes the classical space of complete collineations (arXiv:1702.00120).

T. Milanov had 3 results during 2016. The first one was motivated by the general problem of reconstructing Gromov-Witten (GW) invariants of a smooth projective variety by the monodromy data associated to the Frobenius structure corresponding to the quantum cohomology of the variety. This problem is solved in arXiv:1603.00073 (accepted to the International Journal of Mathematics) for the case of Frobenius structures corresponding to A_N -singularity. The solution is based on the topological recursion of Eynard and Orantin. The result can be viewed as a test of an approach pursued by Milanov to use the topological recursion to reconstruct GW invariants from monodromy data. The second result was a joint work with H. Iritani, Y. Ruan, and Y. Shen (arXiv: 1605.08885, submitted to Transactions of AMS). The main result is a proof of mirror symmetry for the orbifold quotients of the Fermat type Calabi-Yau hypersurfaces quotient by a maximal group of diagonal symmetries. The paper also sets up a general framework to state and investigate mirror symmetry

for all orbifold quotients of hypersurfaces defined by a quasi-homogeneous polynomial. Finally, the third result was a joint work with V. Tonita (arXiv:1610.07223, submitted to Letters in Mathematica Physics). The problem addressed in this paper is to compute K-theoretic GW invariants by the methods of integrable systems. The authors proved that if the K-theoretic quantum product is semi-simple then the genus-0 K-theoretic GW invariants are governed by an integrable hierarchy of hydrodynamic type.

Y. Toda proposed an ansatz for defining Gopakumar-Vafa invariants of Calabi-Yau threefolds, using perverse sheaves of vanishing cycles. The proposal is a modification of a recent approach of Kiem-Li, which is itself based on earlier ideas of Hosono-Saito-Takahashi. The main theorem is that, for local surfaces and irreducible curve classes, the proposed GV invariants agree with another curve counting invariants called Pandharipande-Thomas invariants. This is joint work with D. Maulik, arXiv:1610.07303.

A. Beilinson observed that epsilon factor formalism best fits into the homotopical framework, and he established the theory for Betti cohomology. Using this point of view, T. Abe proved an analogue of localization formula for de Rham epsilon factors, jointly with D. Patel. Now, a big challenge in the theory of ramification is to realize this philosophy for cohomology theory over field of positive characteristics. He is trying to establish the ramification theory from homotopical point of view taking recent big progress in the theory due to Beilinson and T. Saito.

K. Saito, with C. Li, S. Li, Y. Shen, proves for the first time the mirror symmetry relation between the flat potential function of a primitive form and the generating function of Witten invariants of FJRW theory for the cases of central charge greater than 1 (J. Eur. Math. Soc. 9, (2017) 1189–1229). K. Saito shows the coherence of the direct images of relative de Rham complex for a holomorphic map under suitable boundary condition when the critical set lies proper over the base space. K. Saito, with T. Ishibe, shows that the roots of the skew-growth function of a dual Artin monoid are simple and lying in the interval $(0,1]$ and that the smallest root tends to 0 as the rank of the monoid tends to infinity (J. Algebra 480, 2017, 1-21). K. Saito states some general conjectures on the Chapoton polynomial as a two variable generalization of the polynomial, and shows that the conjectures naturally induces the results in the previous work by K. Saito and T. Ishibe, and proves the conjecture for low rank cases.

Why do we exist?

T2K: The T2K collaboration presented its first neutrino oscillation results using a simultaneous analysis of data collected with neutrino and antineutrino beam configurations. By comparing the behavior of neutrinos and antineutrinos, T2K is probing CP violation in the lepton sector. The result, presented at summer 2016 conferences including Neutrino 2016, gives the world's best constraint on the parameter that governs the magnitude of CP violation in neutrino mixing. While the statistical uncertainties are still large, the T2K data is most consistent with a large CP violation. Kavli IPMU members M. Hartz and C. Bronner have played leading roles in the analysis of this data, and the paper describing this measurement has been accepted for publication in Physical Review Letters with the "Editors' Suggestions" designation. T2K has also presented a world-best constraint on the mass splitting and neutrino mixing angle that govern neutrino oscillations in accelerator and atmospheric neutrino experiments. The T2K measurement of the mixing angle is consistent with maximal mixing (45 degrees), while NOvA, a competing experiment in the United States, measures a value that disfavors maximal mixing. Since October 2016, T2K has been collecting data in the neutrino beam configuration, which will increase the experimental sensitivity to the mixing angle and shed more light on the weak tension with NOvA. With data collected through the first half of 2017, T2K will release results at summer 2017 conferences that also include analysis improvements that increase the experimental sensitivity. With a near doubling of neutrino mode data and analysis improvements, they expect to remain at the forefront of the experimental neutrino field.

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 searching 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 has further improved the world best limit for the effective Majorana neutrino mass. An improved upper limit for the effective mass of 61 meV to 165 meV excludes most of the degenerate mass region. It demonstrated the effectiveness of KamLAND-Zen and the ongoing plan to increase the amount of double beta decay by a factor, 2 will stretch the lead in the search for Majorana nature of neutrinos. The result was published in Physical Review Letters with the "Editors' Suggestions".

EGADS: EGADS (Evaluating Gadolinium's Action of Detector Systems) is a 200-ton scale model of Super-Kamiokande enriched with 0.2% gadolinium sulfate in order to make neutron captures visible. It has been operating stably since April 2015. In that time, the water in the tank has been completely recirculated over 350 times, with no detectable loss of gadolinium, while its transparency remains as good as that of the ultrapure water in Super-K. As a result, both the Super-Kamiokande and T2K Collaborations have now officially endorsed and approved the IPMU-originated and IPMU-developed idea of loading Super-K with gadolinium, a concept known as GADZOOKS! (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!). This new phase of operations, formally known as SK-Gd, is expected to get underway in 2018, with the first gadolinium load going into the tank in 2019. In preparation for this, a large new underground experimental hall has been excavated in the Kamioka mine near Super-K. The hall is currently (and rapidly) being filled with scaled-up versions of the Gd-capable water filtration systems demonstrated in EGADS. Since the R&D phase of gadolinium is essentially finished, EGADS is being repurposed into a supernova neutrino detector and its acronym redefined to Employing Gadolinium to Autonomously Detect Supernovas. Its goal is to send 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.

Belle II: The Belle II group of the Kavli IPMU is contributing to the R&D and assembly of the silicon vertex detector (SVD) for the Belle II experiment. The SVD has a four-layer cylindrical structure. Each layer consists of silicon sensor arrays called ladders, and each ladder consists of two to five silicon strip sensors depending on the layer. The Kavli IPMU is responsible to produce twenty outermost-layer ladders. Despite each ladder has to be produced by a series of complicated operations lasting for 15 days, the Belle II group had successfully completed the first assembly of a fully functional ladder in March 2016. The ladder was delegated to the beam test at DESY, and it demonstrated good track finding performance. The Belle II members worked on establishment of the sustainable system of the ladder assembly in 2016. They invited three new full-time operators to our clean room to reinforce our human resource pool, and kicked off a shift system in the clean room to maximize the resource effectiveness and to care operators' health conditions. Approximately doubled human resource allowed us to continuously produce ladders without weekend suspension, and it resulted in reduction of the assembly time cost by two thirds. They also introduced periodical internal reviews of produced ladders' quality. During internal review, they identified systematic shifts of the sensor position in the level of 200 μ m in the assembled ladders, and they improved the assembly procedure to mitigate the shifts. Nine ladders have been produced so far in one year since April 2016. The recent ladders show excellent performance; all sensor displacements from the design position are within +150 μ m, and the number of new electrical defects from the assembly procedure is only two. They estimate that the ladder assembly will be finished by March 2018 from extrapolating the present ladder production rate.

MANGA: This past year has been an eventful one for the MaNGA Survey (PI: K. Bundy, Kavli IPMU Asst. Professor until 2016/9/4 and Visiting Associate Scientist after 2016/9/5). MaNGA (Mapping Nearby Galaxies at Apache Point Observatory) is one of three core programs in the 4th-generation Sloan Digital Sky Survey, and has been collecting integral-field spectroscopy for a vast sample of galaxies since 2014. During this period, MaNGA surpassed all previous efforts to become the largest survey of its kind ever conducted. As of March 2017, the sample size exceeded 4000 galaxies and MaNGA remains on track to reach its goal of 10,000 galaxies by 2020. A wealth of exciting early science results from the survey was published last year. Kavli IPMU postdoc, E. Cheung, worked with K. Bundy to lead a May 2016 Nature publication describing the discovery a new class of galaxy termed "red geysers". These galaxies are devoid of star formation but harbor wide-scale ionized winds of gas — likely launched by central supermassive black holes — that appear to be capable of

heating other sources of ambient gas in these galaxies. Red geysers may therefore provide a vital clue about why galaxies, once quenched of star formation, seldom exhibit renewed bouts of star formation. The discovery was also announced in press releases by Kavli IPMU and other institutions. An additional 19 scientific and technical articles on MaNGA were also published. Topics range from new insights on the origin of ionized gas in early-type galaxies, the role of environment in shaping the radial distribution of different stellar populations, unexpected differences in the distribution and kinematics of gas and stars in galaxies, and the ways in which global scaling relations manifest on local scales.

Supernovae: Kavli IPMU astronomers did various valuable works. The international collaboration led by A. Tolstov and K. Nomoto discovered that the blue color of supernovae during a specific phase could be an indicator for detecting the most distant and oldest supernovae in the Universe – more than 13 billion years old. A team led by E. Sorokina, K. Nomoto, S. Blinnikov and A. Tolstov simulated the violent collisions between supernovae and its surrounding gas, which is ejected before a supernova explosion. This can naturally explain the phenomenon of Superluminous Supernovae that have peak luminosity of one-to-two orders of magnitude higher than normal supernovae.

2. Advancing fusion of various research fields

The Statistical Computational Cosmology CREST project funded by JST is aimed at developing fast imaging data analysis applications for the Subaru HSC survey. In 2016, the CREST team developed a machine-learning classifier of supernovae (M. Morii et al. 2016, PASJ). The classifier has been successfully installed and applied to real data analysis of HSC transient survey started in November. A number of distant Type Ia supernovae with redshifts greater than 1 were identified, several of which have been sent for follow-up observations using Hubble Space Telescope. They also developed an “emulator” for weak lensing signals that is trained with data from one hundred cosmological simulations of structure formation.

In collaboration with N. Lashkari, J. Lin, B. Stoica, and M. Van Raamdonk, H. Ooguri discovered the positivity and monotonicity of the relative entropy in information theory implies a new type of positive energy theorems in General Relativity. Their result generalizes H. Ooguri's paper last year with Lin, Stoica, and a mathematician, M. Marcolli, to a non-perturbative regime. Unlike the traditional positive energy theorems, which assume properties of the energy-momentum tensor in the matter sector of a gravitational theory, the new theorems derived by H. Ooguri and the collaborators are supposed to hold in any low energy effective theory of a consistent quantum theory of gravity. This opened a new approach to study General Relativity using information theory. In another project, in collaboration with D. Harlow to appear soon, H. Ooguri used the holographic principle and information theoretical ideas to prove several “lores” in quantum gravity such as absence of global symmetry and generalized them to a large class of symmetries including discrete symmetries and brane symmetries. In September, H. Ooguri organized a workshop entitled “Statistics, Quantum Information, and Gravity” to explore the emerging interface between high energy theory and gravity with statistics and information theory. H. Murayama's paper with B. Henning, T. Melia, and C. Lu worked out all-order Hilbert series for effective operators in quantum mechanics appeared in *Communications in Mathematical Physics*, an interdisciplinary journal.

In addition to the productive collaborations with KEK, JAXA, and UC Berkeley in POLARBEAR and LiteBIRD, the collaborative works have also evolved. The LiteBIRD team started to collaborate with the Ohsaki group at the Graduate School of Frontier of Sciences for a development of a superconducting magnetic bearing technology and also with the Gonokami-Yumoto-Ideguchi group at Institute for Photon Science and Technology for a laser machining technology.

We regularly host interdisciplinary seminars. In FY2016, we held 68 mathematics-string (MS) theory seminars, and 87 astronomy-particle physics-experimental physics-cosmology (APEC) seminars in addition to 23 special seminars and 6 colloquia. We hosted a conference “Why does the Universe accelerate? Exhaustive study and challenge for the future”. Kavli IPMU and Earth-Life Science Institute (ELSI) of Tokyo Institute of Technology jointly host the 2nd public lecture “A question of Origins”. The public lecture cover the topics related to the origin of space, the Earth, and life. The

audience enjoyed the most advanced science and research in an easy-to-grasp conversation between scientists and philosopher. The Kavli IPMU and the Institute for Cosmic Ray Research (ICRR) held a joint public lecture "Thinking Above the Observable Universe". T. Watari, a Kavli IPMU theoretical physicist, and Y. Ono, ICRR Astronomer, presented their latest topics and talked with each other. The Kavli IPMU held an experimental workshop –Searching for the lost study-Art x Science x Philosophy– where specialists from physics, mathematical philosophy, cognitive science, aesthetics, and contemporary art gave talks about how, why, and what they study. They also talked about the differences and similarities between science and art, both of which were re-born in the modern period.

3. Globalization of the institution

- * Describe what's been accomplished or recognized in the efforts to raise the center's international recognition as a genuine top world-level 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)

From the developmental stage, we have made an effort to bring top-level leaders and talented young researchers from around the world. We have established a fascinating research environment where researchers of different fields work together toward common goals. All of our 19 Principal Investigators (5 non-Japanese: 26%) are world-leading scientists. Other faculty members also play a leading role in each field and include PIs of big international projects such as Belle II, EGADS, Kamland-Zen, SuMIRE, and LiteBIRD. Y. Nomura, a professor of UC Berkeley, is well known in the field of a particle physics and cosmology, has again joined us as a part time staff to teach graduate students at the UTokyo Graduate School of Science. Mikhail Kapranov is a distinguished mathematician and a leader in higher category theory. World-leading theoretical physicists Y. Tachikawa was reappointed as a full time professor. N. Yoshida is also keeping his status as a joint faculty member with the Faculty of Science of UTokyo. All these appointments significantly boost our international standing.

A large fraction of our researchers are non-Japanese. Out of 252 member researchers including faculty, postdoc, affiliate members, and long-time visitors, 102 (41%) are non-Japanese. During FY2016, we had 728 (982) visitors (the numbers in the parentheses take into account multiple visits). Among them, 464 (569) are international and many of them are world-class scientists. The Kavli IPMU has been a key hub for exciting intellectual exchange.

"Program for Advancing strategic international networks to accelerate the circulation of talented researchers" promotes long-term exchanges of talented young researchers between the Kavli IPMU and world-top class foreign universities/institutes for long-term. Under this program, we hosted the conference "Mathematics and Superstring Theory – Unlocking the Mysteries of the Accelerating Universe through Superstring Theory and Astrophysical Observations -".

The Kavli IPMU hosted 14 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 791 participants in total, 248 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 role in different fields.

The Kavli IPMU researchers are encouraged to spend 1-3 months in foreign institutes. This provides great opportunities for collaborative works and raises the visibility of the Kavli IPMU works. They presented numerous seminars and talks at both foreign and domestic institutions and conferences.

The Kavli IPMU signed 17 cooperative research agreements or memorandum of understanding (MOU). In 2016, we conclude a new agreement with the Department of Physics at the University of Oxford for the purpose of the Kavli IPMU Oxford D.Phil. Fellowships. The fellowships are intended to enable doctoral students studying for D.Phil. research degrees in Astrophysics or Particle Physics at U Oxford to be supervised by faculty members of the Kavli IPMU and to provide the opportunity for

the students to conduct research in collaboration with Kavli IPMU researchers. The agreement provides great opportunities for the students at U Oxford and the Kavli IPMU and enforces the globalization of U Tokyo. Also the Kavli IPMU is working very well together with another international graduate program with physics (GSGC). Young students feel attractive function in 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 2016 winter, the Kavli IPMU obtained 595 applicants in total for the postdoctoral positions including Kavli fellows and new CREST fellows and 90% of these are from outside Japan. In total, 15 new postdocs plan to join in FY2017.

Affiliation with the Kavli IPMU is now a successful career path. Our faculty members, K. Bundy and A. Leauthaud were recruited as Associate Researcher and Assistant Professor respectively at UC Santa Cruz. Out of 19 postdocs left from the Kavli IPMU in FY2016, 6 got faculty positions, and 8 got another postdoctoral positions in top universities including University of Oxford, UC Santa Cruz, McGill University, and the Kavli Institute for Astronomy and Astrophysics at Peking University.

Online science news service such as EurekAlert, AlphaGalileo and ResearchSEA have been used effectively to inform our research activities to the world.

4. Implementing organizational reforms

* 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.

Kavli IPMU administrative staff members were awarded the U Tokyo's 2016 Special Prize for business innovation. The team consists of 20 specialized administrators that took part in the "Win-Win projects towards University Globalization". This is the fourth award following 2008, 2013 and 2015.

The Kavli IPMU has already achieved many reforms, including non-traditional tenure positions, merit-based salary system, "nenpo" system, Kavli endowment and naming. Our successful system reforms are expected to spread to the rest of the University and other research institutions to help boost the overall competitiveness of Japan on the global scale. One of successful ripple effects through the host institute has been cross-appointment. It was initiated at the Kavli IPMU and has now spread over not only in the university, but also between other research institutions.

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 (including measures of support by the host institution)

President Gonokami's 'Vision 2020' implies the importance of "Expansion and Establishment of Internationally-renowned Bases for Research". An action to realize this vision, he indicates 'Action 2020' saying "Establish and expand upon internationally-renowned bases for research at the University of 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 the University of Tokyo, and creating new, interdisciplinary knowledge that is the first of its kind in the world."

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 UTokyo to support the Kavli IPMU with top priority. We made the effort to strengthen the University's financial base.

Based on this stance, UTokyo put together a plan for the 5-year extension period and beyond. UTokyo guarantees 10 tenured positions, and permanent assignment of administrative staff. The

budget request from UTokyo to MEXT has also been fully secured for 13 positions and for operation. The University will maintain and hopefully expand the Kavli IPMU even after WPI support finishes. System reform spearheaded by the Kavli IPMU should be expanded to the rest of the University as well as other Universities.

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.

Japanese science documentary special "Hitoshi Murayama's Great Adventures in the Universe – Where did we come from?" was presented by Kavli IPMU director Hitoshi Murayama and aired on NHK on Jan 6, and again as a two-part extended version on NHK BS on Feb 9 and 16. Based on popular demand, the first one was rerun on Feb 5, and latter two in digest versions on March 30 and 31. He was also featured on Fuji BS Galileo-X discussing mystery of vanished anti-matter, and on NHK radio show on Jan 10.

Science movie "The Man from the 9 Dimensions", supervised by H. Ooguri, won Best Educational Production Award at the International Planetarium Society (IPS) Fulldome Festival Brno 2016 held in the Czech Republic.

The Kavli IPMU invited Lisa Randall, a well-known theoretical physicist from Harvard University and held the public lecture "Dark Matter and the Dinosaurs".

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

The University of Tokyo's Kavli IPMU, Institute for Solid State Physics, and Institute for Cosmic Ray Research jointly hosted an event called "Actually I Really Love Physics!–Career Paths of Female Physics Graduates" at the Kavli IPMU and there were 33 participants. This event was held to support female students in physics to plan their careers.

A media artist Norimichi Hirakawa, who makes art works by writing programing codes, stayed to carry out research and make new works at the Kavli IPMU as part of the Artist in Residence (AIR) program. During his stay, through attending teatime and seminars and organizing a workshop, his goal was to land a new prototype for his work. The prototype was exhibited at our open campus at the end of October 2016, and at some art galleries.

Y. Nomura met with philosophers at an event hosted by UTCP (The University of Tokyo Center for Philosophy). He joined the second part of the event, "Headlands of Physics and Philosophy", where presented the latest cosmological theories, including multiverse cosmology, and participated in a discussion with these philosophers.

7. Center's response to the site-visit report

* Transcribe each item from the "Actions required and recommendations" section and note how the center has responded to them. However, if you have already provided this information, please indicate where in the report.

Advice/recommendations from FY 2016 site-visit report

1) The WG is concerned that the machine learning is missing from the present Kavli IPMU effort, and that Kavli IPMU expects that this problem could be solved simply through collaboration. Much serious effort should be put in, as machine learning is an important aspect of any experiment. A task force should be set up to take charge of this problem.

We will set up a task force. Associate Director Nobu Katayama and Naoki Yoshida will lead this effort.

2) Other possible experimental program that can be included in the 5-year plan might be: A dark matter mission, which includes new types of dark matter, other than WIMPS, and SIMP (strong interacting dark matter). Surely these new projects along with those mentioned in II4 will increase the critical mass.

SIMP will be searched for at Belle II. We will assemble a team that can lead the analysis for this search.

3) Three Oxford students came to Kavli IPMU with MOU signed between UT and Oxford University. It is a good start for the foreign student exchange program. This program should be expanded to other first rate foreign graduate schools with oversupply of graduate students such as Berkeley and Princeton. WINGS (World-leading Innovative Graduate Study) is a new graduate program at UT. One new student came to Kavli IPMU through WINGS. The WINGS must be expanded. Also, some mechanism to send UT students to Kavli IPMU must be included in President Gonokami's plans to reform UT.

Before we expand the program to other Universities, we'd like to make sure that the current program with Oxford is successful. We are of course expecting successful results for ongoing students in a couple of years. GCGS, the pilot program for WINGS, has the mechanism to allow more UTokyo (international) students to work at the Kavli IPMU. One Chinese student came to work with N. Katayama through this program.

4) The WG was pleased that Kavli IPMU held exchanges with philosophers. It is worthwhile to reflect on the meaning of the fundamental questions that Kavli IPMU is trying to address. It is an important dimension to add to the center. Clearly, it should go beyond an outreach activity, as it is an important intellectual activity that is relevant to the research of the center.

We have organized a few lectures for general public under collaboration with an ELSI researcher and philosopher under an "Origin" theme. To expand this activity, we are now discussing with UTokyo faculty in philosophy to create a "philosopher in residence" program. Hitoshi Murayama is discussing the matter with Takahiro Nakajima.

5) The WG would like to see more PI contributing to day-to-day activities of Kavli IPMU.

In 2017, we envision 26 PIs among which 8 PIs are international and 10 are on site. It has been 19 PIs and 6 are on site.

World Premier International Research Center Initiative (WPI)

Appendix 1 FY2016 List of Center's Research Results and Main Awards

1. Refereed Papers

- List only the Center's papers published in 2016. (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 whose acknowledgements contain the names of persons affiliated with the WPI program.)
 - B. WPI-related papers
Among papers published in 2016, list those 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 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 language categories when listing them.
 - Assign a serial number to each paper to be used to identify it throughout the system.
- (3) Submission of electronic data
 - In addition to the above, for each paper 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 2016.
 - They will be used as reference in analyzing the trends and states of research in all the WPI centers, 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.

Order of Listing

- A. WPI papers
 1. Original articles

No.	Author names and details
1	Stealth magnetic field in de Sitter spacetime Mukohyama, S PHYSICAL REVIEW D 94(12), 121302, DEC 30 2016
2	Equation of state for SU(3) gauge theory via the energy-momentum tensor under gradient flow Kitazawa, M; Iritani, T; Asakawa, M; Hatsuda, T; Suzuki, H PHYSICAL REVIEW D 94(11), 114512, DEC 21 2016
3	IMPACT OF NEW GAMOW-TELLER STRENGTHS ON EXPLOSIVE TYPE IA SUPERNOVA NUCLEOSYNTHESIS Mori, K; Famiano, MA; Kajino, T; Suzuki, T; Hidaka, J; Honma, M; Iwamoto, K; Nomoto, K; Otsuka, T ASTROPHYSICAL JOURNAL 833(2), 179, DEC 20 2016
4	THE BOSS EMISSION-LINE LENS SURVEY. IV. SMOOTH LENS MODELS FOR THE BELLS GALLERY SAMPLE Shu, YP; Bolton, AS; Mao, S; Kochanek, CS; Perez-Fournon, I; Oguri, M; Montero-Dorta, AD; Cornachione, MA; Marques-Chaves, R; Zheng, Z; Brownstein, JR; Menard, B ASTROPHYSICAL JOURNAL 833(2), 264, DEC 20 2016

5	THE SXDF-ALMA 2 arcmin(2) DEEP SURVEY: STACKING REST-FRAME NEAR-INFRARED SELECTED OBJECTS Wang, WH et al. ASTROPHYSICAL JOURNAL 833(2), 195, DEC 20 2016
6	Astrophysical constraints on dark-matter Q-balls in the presence of baryon-violating operators Cotner, E; Kusenko, A PHYSICAL REVIEW D 94(12), 123006, DEC 12 2016
7	Role of matter in extended quasidilaton massive gravity Gumrukcuoglu, AE; Koyama, K; Mukohyama, S PHYSICAL REVIEW D 94(12), 123510, DEC 12 2016
8	Spacetime equals entanglement Nomura, Y; Salzetta, N; Sanches, F; Weinberg, SJ PHYSICS LETTERS B 763, pp.370-374, DEC 10
9	SUPERNOVAE POWERED BY MAGNETARS THAT TRANSFORM INTO BLACK HOLES Moriya, TJ; Metzger, BD; Blinnikov, SI ASTROPHYSICAL JOURNAL 833(1), 64, DEC 10 2016
10	Angular power spectrum of the diffuse gamma-ray emission as measured by the Fermi Large Area Telescope and constraints on its dark matter interpretation Fornasa, M; Cuoco, A; Zavala, J; Gaskins, JM; Sanchez-Conde, MA; Gomez-Vargas, G; Komatsu, E; Linden, T; Prada, F; Zandanel, F; Morselli, A PHYSICAL REVIEW D 94(12), 123005, DEC 9 2016
11	Monopole operators from the 4-epsilon expansion Chester, SM; Mezei, M; Pufu, SS; Yaakov, I JOURNAL OF HIGH ENERGY PHYSICS (12), , DEC 5 2016
12	SDSS-IV MaNGA IFS GALAXY SURVEY-SURVEY DESIGN, EXECUTION, AND INITIAL DATA QUALITY Yan, RB et al. ASTRONOMICAL JOURNAL 152(6), 197, DEC 2016
13	Transit timing variation and transmission spectroscopy analyses of the hot Neptune GJ3470b Awiphan, S; Kerins, E; Pichadee, S; Komonjinda, S; Dhillon, VS; Rujopakarn, W; Poshyachinda, S; Marsh, TR; Reichart, DE; Ivarsen, KM; Haislip, JB MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(3), pp.2574-2582, DEC
14	Gravitational collapse and the thermal evolution of low-metallicity gas clouds in the early Universe Chiaki, G; Yoshida, N; Hirano, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(3), pp.2781-2798, DEC
15	Type Ia supernovae within dense carbon- and oxygen-rich envelopes: a model for 'Super-Chandrasekhar' explosions? Noebauer, UM; Taubenberger, S; Blinnikov, S; Sorokina, E; Hillebrandt, W MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(3), pp.2972-2985, DEC
16	The HORIZON-AGN simulation: morphological diversity of galaxies promoted by AGN feedback Dubois, Y; Peirani, S; Pichon, C; Devriendt, J; Gavazzi, R; Welker, C; Volonteri, M MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(4), pp.3948-3964, DEC
17	LoCuSS: exploring the selection of faint blue background galaxies for cluster weak-lensing Ziparo, F; Smith, GP; Okabe, N; Haines, CP; Pereira, MJ; Egami, E MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(4), pp.4004-4018, DEC

18	Uncertainties in the production of p nuclei in massive stars obtained from Monte Carlo variations Rauscher, T; Nishimura, N; Hirschi, R; Cescutti, G; Murphy, AS; Heger, A MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(4), pp.4153-4166, DEC
19	W-Algebra constraints and topological recursion for A(N)-singularity (with an Appendix by Danilo Lewanski) Milanov, T; Lewanski, D INTERNATIONAL JOURNAL OF MATHEMATICS 27(13), 1650110, DEC 2016
20	Machine-learning selection of optical transients in the Subaru/Hyper Suprime-Cam survey Morii, M; Ikeda, S; Tominaga, N; Tanaka, M; Morokuma, T; Ishiguro, K; Yamato, J; Ueda, N; Suzuki, N; Yasuda, N; Yoshida, N PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 68(6), 104, DEC 2016
21	Evolution and statistics of non-sphericity of dark matter halos from cosmological N-body simulation Suto, D; Kitayama, T; Nishimichi, T; Sasaki, S; Suto, Y PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 68(6), 97, DEC 2016
22	SDSS-IV MaNGA: A SERENDIPITOUS OBSERVATION OF A POTENTIAL GAS ACCRETION EVENT Cheung, E et al. ASTROPHYSICAL JOURNAL 832(2), 182, DEC 1 2016
23	TWO DISTINCT-ABSORPTION X-RAY COMPONENTS FROM TYPE II _{in} SUPERNOVAE: EVIDENCE FOR ASPHERICITY IN THE CIRCUMSTELLAR MEDIUM Katsuda, S; Maeda, K; Bamba, A; Terada, Y; Fukazawa, Y; Kawabata, K; Ohno, M; Sugawara, Y; Tsuboi, Y; Immler, S ASTROPHYSICAL JOURNAL 832(2), 194, DEC 1 2016
24	THE RESOLVE SURVEY ATOMIC GAS CENSUS AND ENVIRONMENTAL INFLUENCES ON GALAXY GAS RESERVOIRS Stark, DV et al. ASTROPHYSICAL JOURNAL 832(2), 126, DEC 1 2016
25	Two-layer anti-reflection coating with mullite and polyimide foam for large-diameter cryogenic infrared filters Inoue, Y; Hamada, T; Hasegawa, M; Hazumi, M; Hori, Y; Suzuki, A; Tomaru, T; Matsumura, T; Sakata, T; Minamoto, T; Hirai, T APPLIED OPTICS 55(34), pp.D22-D28, DEC 1
26	GALAXY-SCALE GRAVITATIONAL LENS CANDIDATES FROM THE HYPER SUPRIME-CAM IMAGING SURVEY AND THE GALAXY AND MASS ASSEMBLY SPECTROSCOPIC SURVEY Chan, JHH; Suyu, SH; More, A; Oguri, M; Chiueh, T; Coupon, J; Hsieh, BC; Komiyama, Y; Miyazaki, S; Murayama, H; Nishizawa, AJ; Price, P; Tait, PJ; Terai, T; Utsumi, Y; Wang, SY ASTROPHYSICAL JOURNAL 832(2), 135, DEC 1 2016
27	COSMOLOGICAL SIMULATIONS OF EARLY BLACK HOLE FORMATION: HALO MERGERS, TIDAL DISRUPTION, AND THE CONDITIONS FOR DIRECT COLLAPSE Chon, S; Hirano, S; Hosokawa, T; Yoshida, N ASTROPHYSICAL JOURNAL 832(2), 134, DEC 1 2016
28	Quintessential scale dependence from separate universe simulations Chiang, CT; Li, Y; Hu, WN; LoVerde, M PHYSICAL REVIEW D 94(12), 123502, DEC 1 2016
29	SZ effects in the Magneticum Pathfinder simulation: comparison with the Planck, SPT, and ACT results Dolag, K; Komatsu, E; Sunyaev, R MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(2), pp.1797-1811, DEC 1

30	On the faint-end of the high-z galaxy luminosity function Yue, B; Ferrara, A; Xu, YD MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(2), pp.1968-1979, DEC 1
31	Hot Neutron Stars with Hadron-Quark Crossover Masuda, K; Hatsuda, T; Takatsuka, T NUCLEAR PHYSICS A 956, pp.817-820, DEC
32	Nonthermal gravitino production after large field inflation Ema, Y; Mukaida, K; Nakayama, K; Terada, T JOURNAL OF HIGH ENERGY PHYSICS (11), 184, NOV 30 2016
33	Renormalisation group corrections to neutrino mixing sum rules Gehrlein, J; Petcov, ST; Spinrath, M; Titov, AV JOURNAL OF HIGH ENERGY PHYSICS (11), 146, NOV 24 2016
34	Optical and radio astrometry of the galaxy associated with FRB 150418 Bassa, CG; Beswick, R; Tingay, SJ; Keane, EF; Bhandari, S; Johnston, S; Totani, T; Tominaga, N; Yasuda, N; Stappers, BW; Barr, ED; Kramer, M; Possenti, A MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(1), pp.L36-L40, NOV 21
35	SDSS-IV MaNGA: properties of galaxies with kinematically decoupled stellar and gaseous components Jin, YF et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 463(1), pp.913-926, NOV 21
36	A NEW MILKY WAY SATELLITE DISCOVERED IN THE SUBARU/HYPER SUPRIME-CAM SURVEY Homma, D; Chiba, M; Okamoto, S; Komiyama, Y; Tanaka, M; Tanaka, M; Ishigaki, MN; Akiyama, M; Arimoto, N; Garmilla, JA; Lupton, RH; Strauss, MA; Furusawa, H; Miyazaki, S; Murayama, H; Nishizawa, AJ; Takada, M; Usuda, T; Wang, SY ASTROPHYSICAL JOURNAL 832(1), 21, NOV 20 2016
37	SDSS-IV MaNGA: faint quenched galaxies - I. Sample selection and evidence for environmental quenching Penny, SJ et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 462(4), pp.3955-3978, NOV 11
38	Response function of the large-scale structure of the universe to the small scale inhomogeneities Nishimichi, T; Bernardeau, F; Taruya, A PHYSICS LETTERS B 762, pp.247-252, NOV 10
39	WIMP dark matter in a well-tempered regime - A case study on singlet-doublets fermionic WIMP Banerjee, S; Matsumoto, S; Mukaida, K; Tsai, YLS JOURNAL OF HIGH ENERGY PHYSICS (11), 70, NOV 10 2016
40	Measurements of $\pi^{+/-}$ differential yields from the surface of the T2K replica target for incoming 31 GeV/c protons with the NA61/SHINE spectrometer at the CERN SPS Abgrall, N et al. EUROPEAN PHYSICAL JOURNAL C 76(11), 617, NOV 9 2016
41	Flavor physics induced by light Z' from SO(10) GUT Hisano, J; Muramatsu, Y; Omura, Y; Shigekami, Y JOURNAL OF HIGH ENERGY PHYSICS (11), 18, NOV 4 2016
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380	EPR pairs, local projections and quantum teleportation in holography Numasawa, T; Shiba, N; Takayanagi, T; Watanabe, K JOURNAL OF HIGH ENERGY PHYSICS (8), 77, AUG 11 2016
381	Models of a 750 GeV quarkonium and the LHC excesses Hamaguchi, K; Liew, SP PHYSICAL REVIEW D 94(3), 35012, AUG 11 2016
382	Probing the origin of 750 GeV diphoton excess with the precision measurements at the ILC Bae, KJ; Hamaguchi, K; Moroi, T; Yanagi, K PHYSICS LETTERS B 759, pp.575-582, AUG 10
383	Heterotic-type IIA duality and degenerations of K3 surfaces Braun, AP; Watari, T JOURNAL OF HIGH ENERGY PHYSICS (8), 34, AUG 4 2016
384	On SUSY restoration in single-superfield inflationary models of supergravity Ketov, SV; Terada, T EUROPEAN PHYSICAL JOURNAL C 76(8), 438, AUG 4 2016
385	Primordial magnetic fields from the string network Horiguchi, K; Ichiki, K; Sugiyama, N PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (8), 8.3E+03, AUG 2016
386	Extreme asymmetry in the polarized disk of V1247 Orionis Ohta, Y et al. PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 68(4), 53, AUG 2016
387	From the 750 GeV diphoton resonance to multilepton excesses Bae, KJ; Chen, CR; Hamaguchi, K; Low, I PHYSICAL REVIEW D 94(1), 15035, JUL 29 2016
388	The KMOS Redshift One Spectroscopic Survey (KROSS): the Tully-Fisher relation at z similar to 1 Tiley, AL; Stott, JP; Swinbank, AM; Bureau, M; Harrison, CM; Bower, R; Johnson, HL; Bunker, AJ; Jarvis, MJ; Magdis, G; Sharples, R; Smail, I; Sobral, D; Best, P MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 460(1), pp.103-129, JUL 21
389	Exploring the SDSS photometric galaxies with clustering redshifts Rahman, M; Mendez, AJ; Menard, B; Scranton, R; Schmidt, SJ; Morrison, CB; Budavari, T MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 460(1), pp.163-174, JUL 21
390	The galaxy luminosity function in groups and clusters: the faint-end upturn and the connection to the field luminosity function Lan, TW; Menard, B; Mo, HJ MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 459(4), pp.3998-4019, JUL 11
391	HIGH-CONTRAST IMAGING OF INTERMEDIATE-MASS GIANTS WITH LONG-TERM RADIAL VELOCITY TRENDS Ryu, T et al. ASTROPHYSICAL JOURNAL 825(2), 127, JUL 10 2016
392	Detecting black-hole binary clustering via the second-generation gravitational-wave detectors Namikawa, T; Nishizawa, A; Taruya, A PHYSICAL REVIEW D 94(2), 24013, JUL 5 2016
393	Planar Lithographed Superconducting LC Resonators for Frequency-Domain Multiplexed Readout Systems Rotermund, K; Barch, B; Chapman, S; Hattori, K; Lee, A; Palaio, N; Shirley, I; Suzuki, A; Tran, C JOURNAL OF LOW TEMPERATURE PHYSICS 184(1-2), pp.486-491, JUL

394	Classification of differential symmetry breaking operators for differential forms Kobayashi, T; Kubo, T; Pevzner, M COMPTES RENDUS MATHEMATIQUE 354(7), pp.671-676, JUL
395	DISTANT GALAXIES Detection of an oxygen emission line from a high-redshift galaxy in the reionization epoch Inoue, AK; Tamura, Y; Matsuo, H; Mawatari, K; Shimizu, I; Shibuya, T; Ota, K; Yoshida, N; Zackrisson, E; Kashikawa, N; Kohno, K; Umehata, H; Hatsukade, B; Iye, M; Matsuda, Y; Okamoto, T; Yamaguchi, Y SCIENCE 352(6293), pp.1559-1562, JUN 24
396	Frozen singularities in M and F theory Tachikawa, Y JOURNAL OF HIGH ENERGY PHYSICS (6), 128, JUN 21 2016
397	RESOLVE AND ECO: THE HALO MASS-DEPENDENT SHAPE OF GALAXY STELLAR AND BARYONIC MASS FUNCTIONS Eckert, KD; Kannappan, SJ; Stark, DV; Moffett, AJ; Berlind, AA; Norris, MA ASTROPHYSICAL JOURNAL 824(2), 124, JUN 20 2016
398	THE ROLE OF QUENCHING TIME IN THE EVOLUTION OF THE MASS-SIZE RELATION OF PASSIVE GALAXIES FROM THE WISP SURVEY Zanella, A; Scarlata, C; Corsini, EM; Bedregal, AG; Dalla Bonta, E; Atek, H; Bunker, AJ; Colbert, J; Dai, YS; Henry, A; Malkan, M; Martin, C; Rafelski, M; Rutkowski, MJ; Siana, B; Teplitz, H ASTROPHYSICAL JOURNAL 824(2), 68, JUN 20 2016
399	Spectral sum rules for confining large-N theories Cherman, A; McGady, DA; Yamazaki, M JOURNAL OF HIGH ENERGY PHYSICS (6), 95, JUN 17 2016
400	THE IMPOSSIBLY EARLY GALAXY PROBLEM Steinhardt, CL; Capak, P; Masters, D; Speagle, JS ASTROPHYSICAL JOURNAL 824(1), 21, JUN 10 2016
401	Diphoton excess and running couplings Bae, KJ; Endo, M; Hamaguchi, K; Moroi, T PHYSICS LETTERS B 757, pp.493-500, JUN 10
402	Planck constraints on scalar-tensor cosmology and the variation of the gravitational constant Ooba, J; Ichiki, K; Chiba, T; Sugiyama, N PHYSICAL REVIEW D 93(12), 122002, JUN 2 2016
403	Occam's razor in lepton mass matrices: The sign of the universe's baryon asymmetry Kaneta, Y; Shimizu, Y; Tanimoto, M; Yanagida, TT PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (6), 063B03, JUN 2016
404	THE COMPOSITE SPECTRUM OF BOSS QUASARS SELECTED FOR STUDIES OF THE Ly alpha FOREST Harris, DW; Jensen, TW; Suzuki, N; Bautista, JE; Dawson, KS; Vivek, M; Brownstein, JR; Ge, J; Hamann, F; Herbst, H; Jiang, LH; Moran, SE; Myers, AD; Olmstead, MD; Schneider, DP ASTRONOMICAL JOURNAL 151(6), 155, JUN 2016
405	Polarization angle swings in blazars: The case of 3C 279 Kiehlmann, S et al. ASTRONOMY & ASTROPHYSICS 590, A10, JUN 2016
406	Suppressing star formation in quiescent galaxies with supermassive black hole winds Cheung, E et al. NATURE 533(7604), pp.504-+, MAY 26

407	DETECTION OF LENSING SUBSTRUCTURE USING ALMA OBSERVATIONS OF THE DUSTY GALAXY SDP. 81 Hezaveh, YD; Dalal, N; Marrone, DP; Mao, YY; Morningstar, W; Wen, D; Blandford, RD; Carlstrom, JE; Fassnacht, CD; Holder, GP; Kembell, A; Marshall, PJ; Murray, N; Levasseur, LP; Vieira, JD; Wechsler, RH ASTROPHYSICAL JOURNAL 823(1), 37, MAY 20 2016
408	RG flow and thermodynamics of causal horizons in higher-derivative AdS gravity Banerjee, S; Bhattacharyya, A JOURNAL OF HIGH ENERGY PHYSICS (5), 126, MAY 20 2016
409	Bethe subalgebras in affine Birman-Murakami-Wenzl algebras and flat connections for q-KZ equations Isaev, AP; Kirillov, AN; Tarasov, VO JOURNAL OF PHYSICS A-MATHEMATICAL AND THEORETICAL 49(20), 204002, MAY 20 2016
410	Be STARS IN THE OPEN CLUSTER NGC 6830 Yu, PC et al. ASTRONOMICAL JOURNAL 151(5), 121, MAY 2016
411	Millimeter-wave broadband antireflection coatings using laser ablation of subwavelength structures Matsumura, T; Young, K; Wen, Q; Hanany, S; Ishino, H; Inoue, Y; Hazumi, M; Koch, J; Suttman, O; Schutz, V APPLIED OPTICS 55(13), pp.3502-3509, MAY 1
412	Level crossing between the QCD axion and an axionlike particle Daido, R; Kitajima, N; Takahashi, F PHYSICAL REVIEW D 93(7), 75027, APR 19 2016
413	Differential symmetry breaking operators: I. General theory and F-method Kobayashi, T; Pevzner, M SELECTA MATHEMATICA-NEW SERIES 22(2), pp.801-845, APR
414	Differential symmetry breaking operators: II. Rankin-Cohen operators for symmetric pairs Kobayashi, T; Pevzner, M SELECTA MATHEMATICA-NEW SERIES 22(2), pp.847-911, APR
415	Design and Performance of a Prototype Polarization Modulator Rotational System for Use in Space Using a Superconducting Magnetic Bearing Matsumura, T; Kataza, H; Utsunomiya, S; Yamamoto, R; Hazumi, M; Katayama, N IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY 26(3), 3602304, APR 2016
416	Occam's razor in quark mass matrices Tanimoto, M; Yanagida, TT PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (4), 043B03, APR 2016
417	MAXIMAL SEMIGROUP SYMMETRY AND DISCRETE RIESZ TRANSFORMS Kobayashi, T; Nilsson, A; Sato, F JOURNAL OF THE AUSTRALIAN MATHEMATICAL SOCIETY 100(2), pp.216-240, APR
418	Near-infrared imaging polarimetry of LkCa 15: A possible warped inner disk Oh, D et al. PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 68(2), L3, APR 2016
419	AGN host galaxy mass function in COSMOS Is AGN feedback responsible for the mass-quenching of galaxies? Bongiorno, A; Schulze, A; Merloni, A; Zamorani, G; Ilbert, O; La Franca, F; Peng, Y; Piconcelli, E; Mainieri, V; Silverman, JD; Brusa, M; Fiore, F; Salvato, M; Scoville, N ASTRONOMY & ASTROPHYSICS 588, A78, APR 2016

420	Bethe's quantum numbers and rigged configurations Kirillov, AN; Sakamoto, R NUCLEAR PHYSICS B 905, pp.359-372, APR
421	Anisotropies of Gravitational-Wave Standard Sirens as a New Cosmological Probe without Redshift Information Namikawa, T; Nishizawa, A; Taruya, A PHYSICAL REVIEW LETTERS 116(12), 121302, MAR 24 2016
422	KROSS: mapping the Ha emission across the star formation sequence at z approximate to 1 Magdis, GE; Bureau, M; Stott, JP; Tiley, A; Swinbank, AM; Bower, R; Bunker, AJ; Jarvis, M; Johnson, H; Sharples, R MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 456(4), pp.4533-4541, MAR 11
423	Renormalized entanglement entropy on cylinder Banerjee, S; Nakaguchi, Y; Nishioka, T JOURNAL OF HIGH ENERGY PHYSICS (3), 48, MAR 9 2016
424	Prospects for Higgs- and Z-resonant neutralino dark matter Hamaguchi, K; Ishikawa, K PHYSICAL REVIEW D 93(5), 55009, MAR 9 2016
425	Perverse sheaves over real hyperplane arrangements Kapranov, M; Schechtman, V ANNALS OF MATHEMATICS 183(2), pp.619-679, MAR
426	THE X-RAY ZURICH ENVIRONMENTAL STUDY (X-ZENS). II. X-RAY OBSERVATIONS OF THE DIFFUSE INTRAGROUP MEDIUM IN GALAXY GROUPS Miniati, F; Finoguenov, A; Silverman, JD; Carollo, M; Cibinel, A; Lilly, SJ; Schawinski, K ASTROPHYSICAL JOURNAL 819(1), 26, MAR 1 2016
427	PROPERTIES OF THE INTERSTELLAR MEDIUM IN STAR-FORMING GALAXIES AT z similar to 1.4 REVEALED WITH ALMA Seko, A; Ohta, K; Yabe, K; Hatsukade, B; Akiyama, M; Iwamuro, F; Tamura, N; Dalton, G ASTROPHYSICAL JOURNAL 819(1), 82, MAR 1 2016
428	Gravitational waves from the first order phase transition of the Higgs field at high energy scales Jinno, R; Nakayama, K; Takimoto, M PHYSICAL REVIEW D 93(4), 45024, FEB 22 2016
429	Black hole formation and growth with non-Gaussian primordial density perturbations Habouzit, M; Volonteri, M; Latif, M; Nishimichi, T; Peirani, S; Dubois, Y; Mamon, GA; Silk, J; Chevallard, J MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 456(2), pp.1901-1912, FEB 21
430	Reheating signature in the gravitational wave spectrum from self-ordering scalar fields Kuroyanagi, S; Hiramatsu, T; Yokoyama, J JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (2), 23, FEB 2016
431	XMASS detector calibration using a neutron source Ichimura, K JOURNAL OF INSTRUMENTATION 11, C02034, FEB 2016
432	THE SDSS-IV EXTENDED BARYON OSCILLATION SPECTROSCOPIC SURVEY: OVERVIEW AND EARLY DATA Dawson, KS et al. ASTRONOMICAL JOURNAL 151(2), 44, FEB 2016

433	Dust attenuation in z similar to 1 galaxies from Herschel and 3D-HST H alpha measurements Puglisi, A; Rodighiero, G; Franceschini, A; Talia, M; Cimatti, A; Baronchelli, I; Daddi, E; Renzini, A; Schawinski, K; Mancini, C; Silverman, J; Gruppioni, C; Lutz, D; Berta, S; Oliver, SJ ASTRONOMY & ASTROPHYSICS 586, A83, FEB 2016
434	SHADOW OF A COLOSSUS: A $z=2.44$ GALAXY PROTOCLUSTER DETECTED IN 3D Ly alpha FOREST TOMOGRAPHIC MAPPING OF THE COSMOS FIELD Lee, KG; Hennawi, JF; White, M; Prochaska, JX; Font-Ribera, A; Schlegel, DJ; Rich, RM; Suzuki, N; Stark, CW; Le Fevre, O; Nugent, PE; Salvato, M; Zamorani, G ASTROPHYSICAL JOURNAL 817(2), 160, FEB 1 2016
435	THE SPLASH SURVEY: QUIESCENT GALAXIES ARE MORE STRONGLY CLUSTERED BUT ARE NOT NECESSARILY LOCATED IN HIGH-DENSITY ENVIRONMENTS Lin, L; Capak, PL; Laigle, C; Ilbert, O; Hsieh, BC; Jian, HY; Lemaux, BC; Silverman, JD; Coupon, J; McCracken, HJ; Hasinger, G; Le Fevre, O; Scoville, N ASTROPHYSICAL JOURNAL 817(2), 97, FEB 1 2016
436	Starobinsky-like two-field inflation Kaneda, S; Ketov, SV EUROPEAN PHYSICAL JOURNAL C 76(1), 26, JAN 20 2016
437	THE UNUSUAL SUPER-LUMINOUS SUPERNOVAE SN 2011KL AND ASASSN-15LH Bersten, MC; Benvenuto, OG; Orellana, M; Nomoto, K ASTROPHYSICAL JOURNAL LETTERS 817(1), L8, JAN 20 2016
438	SDSS-III Baryon Oscillation Spectroscopic Survey Data Release 12: galaxy target selection and large-scale structure catalogues Reid, B et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 455(2), pp.1553-1573, JAN 11
439	Poincare series for non-Riemannian locally symmetric spaces Kassel, F; Kobayashi, T ADVANCES IN MATHEMATICS 287, pp.123-236, JAN 10
440	Single-superfield helical-phase inflation Ketov, SV; Terada, T PHYSICS LETTERS B 752, pp.108-112, JAN 10
442	Stable pair invariants on Calabi-Yau threefolds containing P-2 Toda, Y GEOMETRY & TOPOLOGY 20(1), pp.555-611,
443	Gepner Type Stability Condition via Orlov/Kuznetsov Equivalence Toda, Y INTERNATIONAL MATHEMATICS RESEARCH NOTICES (1), pp.24-82,
444	Notes on Schubert, Grothendieck and Key Polynomials Kirillov, AN SYMMETRY INTEGRABILITY AND GEOMETRY-METHODS AND APPLICATIONS 12, 34, 2016
445	Double-trace deformations and entanglement entropy in AdS Miyagawa, T; Shiba, N; Takayanagi, T FORTSCHRITTE DER PHYSIK-PROGRESS OF PHYSICS 64(1), pp.92-105, JAN
446	ON THE METALLICITY AND ORIGIN OF THE SMITH HIGH-VELOCITY CLOUD Fox, AJ; Lehner, N; Lockman, FJ; Wakker, BP; Hill, AS; Heitsch, F; Stark, DV; Barger, KA; Sembach, KR; Rahman, M ASTROPHYSICAL JOURNAL LETTERS 816(1), L11, JAN 1 2016

447	PHYSICAL PROPERTIES OF SPECTROSCOPICALLY CONFIRMED GALAXIES AT $z \geq 6$. III. STELLAR POPULATIONS FROM SED MODELING WITH SECURE Ly alpha EMISSION AND REDSHIFTS Jiang, LH; Finlator, K; Cohen, SH; Egami, E; Windhorst, RA; Fan, XH; Dave, R; Kashikawa, N; Mechtley, M; Ouchi, M; Shimasaku, K; Clement, B ASTROPHYSICAL JOURNAL 816(1), 16, JAN 1 2016
448	Probing high-redshift galaxies with Ly alpha intensity mapping Comaschi, P; Ferrara, A MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 455(1), pp.725-738, JAN 1
449	Lagrangian Torus Fibrations and Homological Mirror Symmetry for the Conifold Chan, K; Pomerleano, D; Ueda, K COMMUNICATIONS IN MATHEMATICAL PHYSICS 341(1), pp.135-178, JAN
450	On Some Quadratic Algebras I 1/2: Combinatorics of Dunkl and Gaudin Elements, Schubert, Grothendieck, Fuss-Catalan, Universal Tutte and Reduced Polynomials Kirillov, AN SYMMETRY INTEGRABILITY AND GEOMETRY-METHODS AND APPLICATIONS 12, 2, 2016

2. Review articles

No.	Author names and details
441	A Review on Instanton Counting and W-Algebras Tachikawa, Y NEW DUALITIES OF SUPERSYMMETRIC GAUGE THEORIES, pp.79-120, 2016

3. Proceedings

N/A

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 FY2016 in order from most recent.
- For each, write the lecturer/presenter's name, presentation title, conference name and date(s)

No.	Lecturer/presenter names and details
1	Masayuki Nakahata "Supernova Neutrino Detection Overview" (Invited speaker) 8th Symposium on Large TPCs for Low-Energy Rare Event Detection Paris, France, Dec 7, 2016
2	Tsutomu Yanagida "Neutrino Masses in the Landscape of Vacua" (Invited speaker) The 13 th International Symposium on Cosmology and Particle Astrophysics The University of Sydney, Australia, Nov 28 – Dec 2, 2016
3	Ken'ichi Nomoto "Superluminous Supernovae: Constraints on Progenitors and Explosion" (invited speaker) IAU Symposium 329 "The Lives and Death-Throes of Massive Stars" Auckland, New Zealand, Nov 28, 2016
4	Yuji Tachikawa "On 4d N=3 theories" (Invited speaker) Symposium to celebrate the 75 th Birthday of John Schwarz (JHS85) Caltech, Pasadena, USA, Nov 19, 2016
5	Kentaro Hori "2d Seiberg duality, with boundary" Strings and Geometry KIAS, Seoul, South Korea, Oct 24 – 26, 2016
6	Mark Vagins "Supernova Neutrinos: MeV Messengers of the Extreme" (plenary talk) TeV Particle Astrophysics 2016 (TeVPA16) CERN, Geneva, Switzerland, Sep 13, 2016
7	Mark Hartz "The Hyper-K Experiment" (plenary talk) NuFact16: International Workshop on Neutrino Factories and Future Neutrino Facilities ICISE, Quy Nhon, Vietnam, Aug 26, 2016
8	Hiroshi Ooguri "Gravitational Positive Energy Theorems from Information Inequalities" Strings 2016 Tsinghua University, China, Aug 2, 2016
9	Hitoshi Murayama "Outlook" (Plenary talk) SUSY2016 The University of Melbourne, Jul 3 – 8, 2016
10	Masahiro Takada "Neutrinos from lensing surveys" (Invited speaker) Neutrinos and Light Particles in Cosmology UC Berkeley, USA, Jun 22 – 24, 2016

3. Major Awards

- List up to 10 main awards received during FY2016 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.

No.	Recipient names and details
1	Tomoyuki Abe MSJ Spring Prize Mar 2017
2	Yuki Sakurai Young Scientist Award of the Physical Society of Japan Mar 2017
3	Naoki Yoshida Japan Academy Medal Jan 2017
4	Taruya Atsushi Yukawa-Kimura Prize Jan 2017
5	Naoki Yoshida The Japan Society for the Promotion of Science Award Dec 2016
6	Kyoji Saito Kiyoshi Oka Prize Dec 2016
7	Tadashi Takayanagi Nishina Memorial Prize Nov 2016
8	Takaaki Kajita Chunichi Cultural Award Jun 2016
9	Hiroshi Ooguri Chunichi Cultural Award Jun 2016
10	Hiroshi Ooguri Best Educational Production Award Jun 2016

World Premier International Research Center Initiative (WPI) Appendix 2 FY 2016 List of Principal Investigators

NOTE:

- Underline names of principal investigators who belong to an overseas research institution.
- In case of researchers not listed in the latest report, attach "Biographical Sketch of a New Principal Investigator".

<Results at the end of FY2016>								Principal Investigators Total: 19		
Name (Age)	Affiliation (Position title, department, organization)	Academic degree specialty	Working hours (Total working hours: 100%)				Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions	
			work on center project		Others					
			Research activities	Other activities	Research activities	Other activities				
Center director <u>Hitoshi Murayama</u> (53)	Kavli IPMU (Director, Project Professor), University of California, Berkeley (Professor, Physics Dept)	Ph.D. particle theory, cosmology	45%	40%	0%	15%	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 (2 weeks each) and 2 senior scientists (1 week each). Accepting 5 young scientists (2 weeks each).	
Yoichiro Suzuki (67)	Kavli IPMU (Deputy Director, Project Professor)	Ph.D. astroparticle physics	70%	5%	5%	20%	10/1/2007	Branch. Joins videoconference once a week		
Hiroaki Aihara (61)	Kavli IPMU (Deputy Director) Utkyo (Executive Vice President, Physics Dept)	Ph.D. high energy physics	25%	5%	0%	70%	10/1/2007	Stays at Kavli IPMU once a month. Joins videoconference once a week.		
<u>Alexey Bondal</u> (55)	Steklov Mathematical Institute (Professor) Kavli IPMU (Project Professor)	Ph.D. mathematics	40%	0%	40%	20%	10/1/2007	Stays at Kavli IPMU 6 months a year. Joins videoconference once a week for the rest of 6 months.	Sending 1 senior scientist (2 weeks).	
Kunio Inoue (51)	Tohoku University (Director, Professor, RCNS)	Ph.D. astroparticle physics	45%	0%	5%	50%	10/1/2007	Stays at Kamioka Branch once a week.		
Takaaki Kajita (58)	U Tokyo (Director, Professor, ICRR)	Ph.D. astroparticle physics	40%	0%	0%	60%	10/1/2007	Stays at Kamioka Branch once a month. Usually stays at ICRR which is right next to Kavli IPMU		
<u>Stavros Katsanevas</u> (63)	University of Paris 7 (Professor, Physics Dept)	Ph.D. astroparticle physics	20%	0%	10%	70%	10/1/2007	Stays at Kavli IPMU once a year. Joins videoconference once a month	Sending 1 young scientist to Kavli IPMU (3 weeks)	
Masahiro Kawasaki (56)	U Tokyo (Professor, ICRR)	Ph.D. particle cosmology	40%	0%	40%	20%	8/1/2015	Stays at Kavli IPMU twice a week.		
Toshiyuki Kobayashi (54)	U Tokyo (Professor, ICRR)	Ph.D. mathematics	70%	0%	8%	22%	6/1/2011	Stays at Kavli IPMU once a month. Joins videoconference once a month		
Toshitake Kohno (61)	U Tokyo (Professor, Graduate School of Mathematical Sciences)	Ph.D. mathematics	70%	0%	8%	22%	10/1/2007	Stays at Kavli IPMU once a week. Joins videoconference once a week.		
Masayuki Nakahata (57)	U Tokyo (Professor, ICRR)	Ph.D. astroparticle physics	85%	0%	9%	6%	10/1/2007	Usually stays at Kamioka Branch.		
Mihoko Nojiri (54)	KEK (Professor)	Ph.D. particle theory	40%	0%	40%	20%	10/1/2007	Stays at Kavli IPMU twice a week.		
Ken'ichi Nomoto (70)	Kavli IPMU (Project Professor) Hamamatsu Professor	Ph.D. cosmology	70%	0%	12%	18%	10/1/2007	Stays at Kavli IPMU full time.		
<u>Hiroshi Ooguri</u> (55)	California Institute of Technology (Professor, Physics Dept and Mathematics Dept)	Ph.D. string theory	66%	0%	3%	31%	10/1/2007	Stays at Kavli IPMU 3 months a year. Joins videoconference once a week for the rest of 9 months.	Sending 1 young scientist (2 weeks). Accepting 2 young scientists	
Kyoji Saito (72)	Kavli IPMU (Project Professor)	Ph.D. mathematics	80%	20%	0%	0%	10/1/2007	Stays at Kavli IPMU full time.		

<u>David Spergel</u> (56)	Princeton University (Professor, Dept of Astrophysical Sciences)	Ph.D. cosmology	55%	0%	5%	40%	10/1/2007	Stays at Kavli IPMU once a year. Joins videoconference once a week.	Sending 1 professor (1 month), 4 young scientists (2 weeks each).
<u>Henry Sobel</u> (73)	University of California Irvine (Professor, Dept of Physics and Astronomy)	Ph.D. astroparticle physics	50%	0%	13%	37%	10/1/2007	Stays at Kamioka Branch 4 times a year. Joins videoconference once a week.	Sending 7 young scientists (3 weeks each).
Naoshi Sugiyama (55)	Nagoya University (Professor, Physics Dept)	Ph.D. cosmology	47%	0%	3%	50%	10/1/2007	Stays at Kavli IPMU once a month. Joins videoconference once a week.	
Tsutomu Yanagida (68)	Kavli IPMU (Project Professor)	Ph.D. particle theory	90%	0%	0%	10%	10/1/2007	Stays at Kavli IPMU full time.	

The University of Tokyo -1

Kavli IPMU

World Premier International Research Center Initiative (WPI)

Appendix 3-1 FY2016 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

- Enter the total number of people in the columns below. In the "Researchers" column, put the number and percentage of overseas researchers in the < > brackets and the number and percentage of female researchers in the [] brackets.
- In the "Administrative staffs" column, put the number and percentage of bilingual staffs in the () brackets.
- In the "Final Goal" column, enter the currently projected goal and the estimated date for achieving it [OO month, OO year].

	Goal set in the "Post-interim evaluation revised center project"	Results at end of FY 2016	Final goal (Date: 4, 2022)
Researchers	213 <83, 39%> [5, 2%]	252 <102, 40.5%> [14, 5.6%]	213 <83, 39%> [5, 2%]
Principal investigators	22 <8, 36%> [1, 5%]	19 <5, 26.3%> [1, 5.3%]	22 <8, 36%> [1, 5%]
Other researcher	191 <75, 39%> [4, 2%]	233 <98, 42.1%> [13, 5.6%]	191 <75, 39%> [4, 2%]
Research support staffs	28	29	28
Administrative staffs	10 (3, 30%)	10 (3, 30%)	10 (3, 30%)
Total	251	291	251

Other matters of 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 PI candidates on site is K. Hori, K. U. Martens, S. Matsumoto, S. Moriyama, M. Takada, Y. Toda, M. Vagins, and N. Yoshida. The other PI candidates are Y. K. Kim, leaders 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. In this plan, the number of PIs will increase to be 26 and their averaged age is 52 (63 for current PIs) as of 2017.

- As background to how the Center is working to mobilize/circulate the 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 FY2016, we hired 24 postdoctoral researchers including 2 JSPS fellows, and 22 had left Kavli IPMU. The hired postdocs came from different foreign university/institutes including Yale U, U Penn, Johns Hopkins U, Duke U, Imperial College London, Durham U, Leiden U, Institut des Hautes Études Scientifiques (IHES), U Melbourne, Hebrew U of Jerusalem, National Tsing Hua U, Chinese University Hong Kong, Indian Institute of Science. Out of 19 postdocs who left Kavli IPMU during FY2016, 6 got faculty positions including 3 associate professors (Osaka U, ASIAA, and Moscow Institute of Physics and Technology) and 8 got another appointment including Newton International Fellow at U Oxford and postdocs at top universities including UC Santa Cruz, McGill U, Kavli Institute for Astronomy and Astrophysics at Peking University.

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	

< Partner institutions>

Institution name	Principal Investigator(s), if any	Notes
Institut des Hautes Etudes 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 competitive research funding

Competitive and other research funding secured in FY2016

Total: 1,328M yen

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

- 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–"
215.1M yen
- Japan Science and Technology Agency (JST)
CREST Project "Statistical Computational Cosmology with Big Astronomical Imaging Data"
49M yen
- Japan Society for the Promotion of Science (JSPS)
Program for Advancing Strategic International Networks to Accelerate the Circulation of Talented Researchers "Mathematics and Superstring Theory – Unlocking the Mysteries of the Accelerating Universe through Superstring Theory and Astrophysical Observations –"
41.82M yen
- Japan Society for the Promotion of Science (JSPS)
Core-to-Core Program "International Center for Observational Proof of Inflationary Universe"
14.85M yen

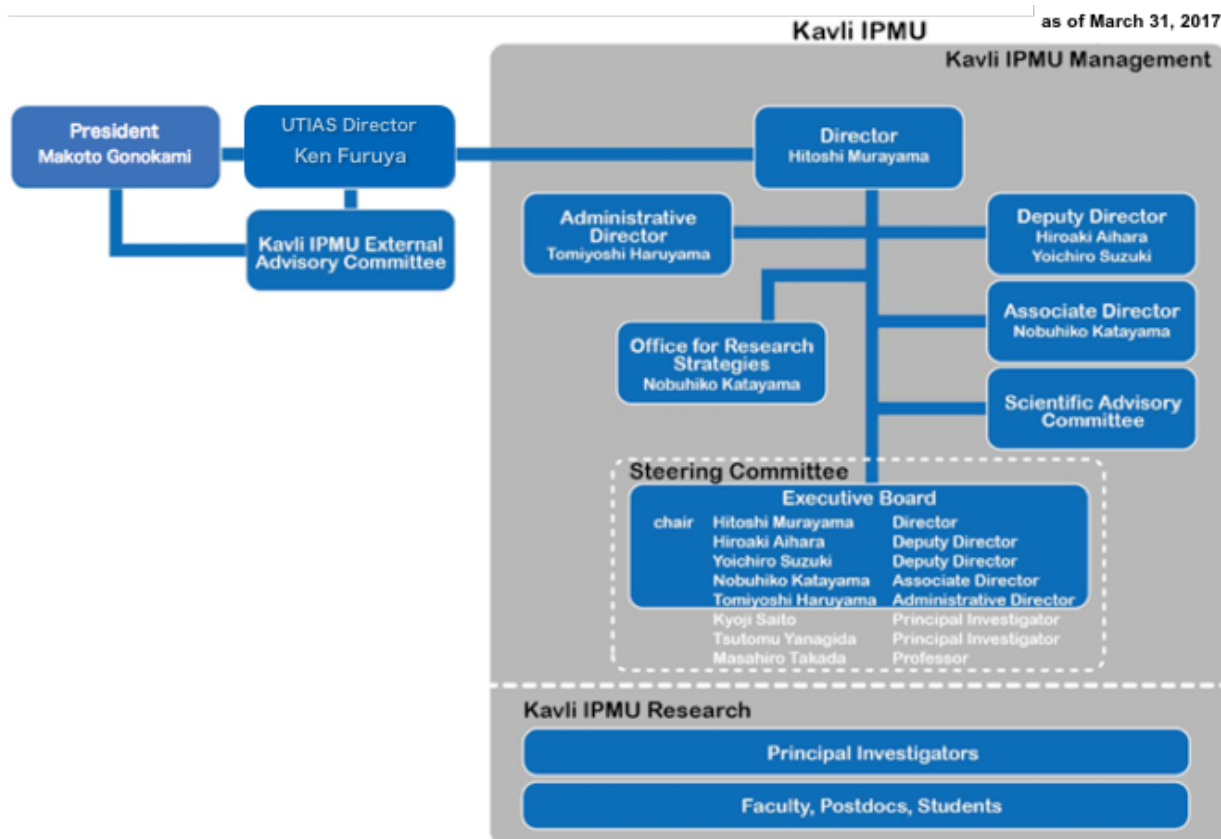
3. International research conferences or symposiums held to bring world's leading researchers together

- Indicate the number of international research conferences or symposiums held in FY2016 and give up to three examples of the most representative ones using the table below.

FY 2016: 14 meetings	
Major examples (meeting titles and places held)	Number of participants
"PHYSTAT-nu Workshop on Statistical Issues in Experimental Neutrino Physics" Lecture Hall, Kavli IPMU	From domestic institutions: 21 From overseas institutions: 68
"HSC Collaboration meeting" Lecture Hall, Seminar Room A and B, Kavli IPMU	From domestic institutions: 83 From overseas institutions: 33
"D-modules and Hodge theory" Lecture Hall, Kavli IPMU	From domestic institutions: 45 From overseas institutions: 12

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 "Post-interim evaluation revised center project," please describe them. Please describe any changes made in the administrative director, head of host institution, and officer(s) in charge at the host institution (e.g., executive vice president for research)



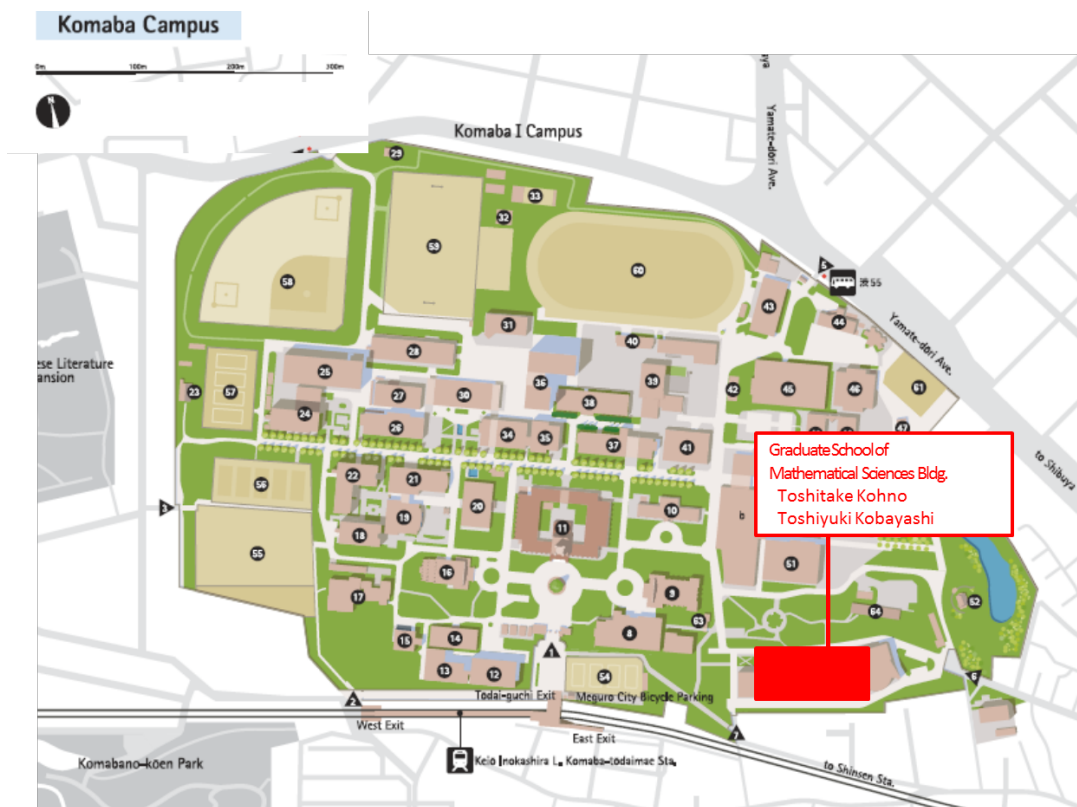
5. Campus Map

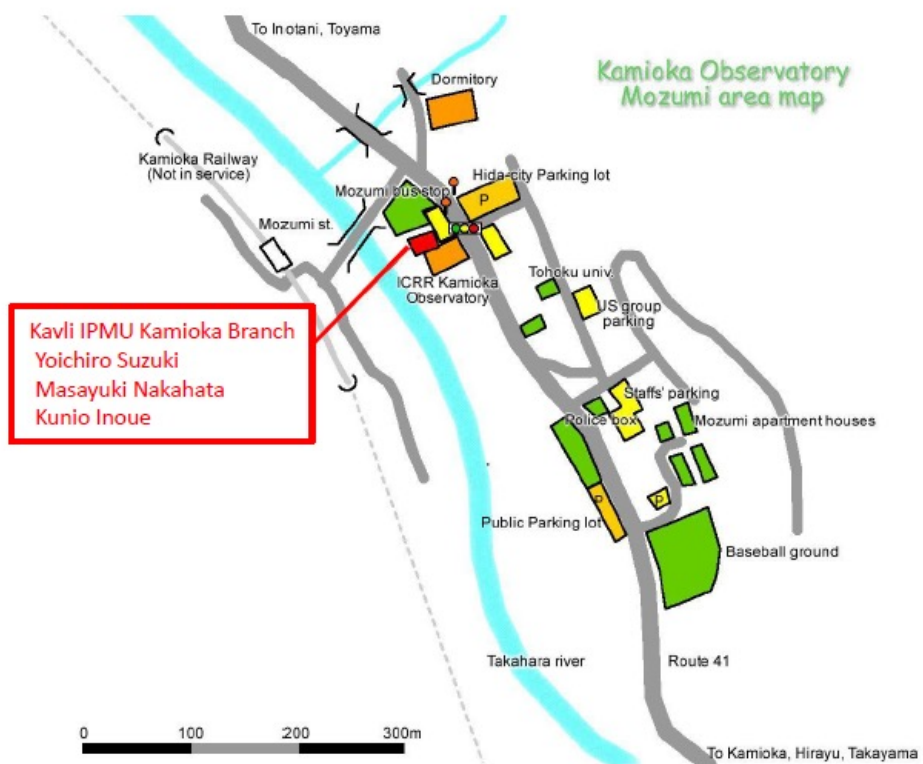
- Please draw a simple map of the campus showing where the main office and principle investigator(s) are located.



Kashiwa Campus







World Premier International Research Center Initiative (WPI)

Appendix 3-2 6. Project Expenditures (the exchange rate used: 1USD= 100JPY)

1) Overall project funding

Cost Items	Details	Costs (Ten thousand dollars)		Costs (Ten thousand dollars)
			WPI grant	0
Personnel	Center director and Administrative director	37		
	Principal investigators (no. of persons):9	90	Costs of establishing and maintaining facilities	0
	Other researchers (no. of persons):113	656		
	Research support staffs (no. of persons):28	88		
	Administrative staffs (no. of persons):11	77		
	Total	948		
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):14	23		
	Cost of dispatching scientists (no. of persons):1	1		
	Research startup cost (no. of persons):44	24	Cost of equipment procured	131
	Cost of satellite organizations (no. of satellite organizations):1	22	Cooling system for testing polarized modulator	33
	Cost of international symposiums (no. of symposiums):14	2	Number of units:1	
	Rental fees for facilities	221	Sapphire patterning laser equipment for polarized modulator	16
	Cost of consumables	131	Number of units:1	
	Cost of utilities	29	Rotary cryostat for testing polarized modulator	16
	Other costs	166	Number of units:1	
	Total	619	Computers for low-background underground experiments	16
Travel	Domestic travel costs	6	Number of units:1	
	Overseas travel costs	43	Renewal cost of Wireless LAN system in Kavli IPMU	7
	Travel and accommodations cost for invited scientists (no. of domestic scientists):15 (no. of overseas scientists):150	27	Number of units:1	
	Travel cost for scientists on secondment (no. of domestic scientists):1 (no. of overseas scientists):12	6		
	Total	82	Others	43
Equipment	Depreciation of buildings	109		
	Depreciation of equipment	278		
	Total	387		
Other research projects	Projects supported by other government subsidies, etc.	1,000		
	Commissioned research projects, etc.	75		
	Grants-in-Aid for Scientific Research, etc.	791		
	Total	1,866		
	Total	3,902		

The University of Tokyo -1

Kavli IPMU
Appendix 3-2

2) Costs of Satellites and Partner institutions

Cost Items	Details	Costs (Ten thousand dollars)
Personnel	Principal investigators (no. of persons):0	20.5
	Other researchers (no. of persons):5	
	Research support staffs (no. of persons):0	
	Administrative staffs (no. of persons):0	
	Total	20.5
Project activities		1
Travel		0.5
Equipment		0
Other research projects		0
	Total	22

The University of Tokyo -2

Kavli IPMU

World Premier International Research Center Initiative (WPI) Appendix4 FY2016 Status of Collaboration with Overseas Satellites

1. Coauthored Papers

- List the refereed papers published in FY2016 that were coauthored between the center's researcher(s) in domestic institution(s) 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. 2017 and not described in Appendix 1.

Overseas Satellite 1 (Total: 6 papers)

No.	Author names and details
1-66	A SEARCH FOR ELECTRON ANTINEUTRINOS ASSOCIATED WITH GRAVITATIONAL-WAVE EVENTS GW150914 AND GW151226 USING KAMLAND Gando, A et al. (including <i>Fujikawa, B</i>) ASTROPHYSICAL JOURNAL LETTERS 829(2), L34, OCT 1 2016
1-115	Search for Majorana Neutrinos Near the Inverted Mass Hierarchy Region with KamLAND-Zen Gando, A et al. (including <i>Fujikawa, B</i>) PHYSICAL REVIEW LETTERS 117(8), 82503, AUG 16 2016
1-140	The POLARBEAR-2 and the Simons Array Experiments Suzuki, A et al. (including <i>Lee, AT</i>) JOURNAL OF LOW TEMPERATURE PHYSICS 184(3-4), pp.805-810, AUG 2016
1-141	LiteBIRD: Mission Overview and Focal Plane Layout Matsumura, T et al. (including <i>Lee, AT</i>) JOURNAL OF LOW TEMPERATURE PHYSICS 184(3-4), pp.824-831, AUG
1-163	Development of Readout Electronics for POLARBEAR-2 Cosmic Microwave Background Experiment Hattori, K et al. (including <i>Lee, AT</i>) JOURNAL OF LOW TEMPERATURE PHYSICS 184(1-2), pp.512-518, JUL 2016
1-393	Planar Lithographed Superconducting LC Resonators for Frequency-Domain Multiplexed Readout Systems Rotermund, K; Barch, B; Chapman, S; Hattori, K; <i>Lee, A</i> ; Palaio, N; Shirley, I; Suzuki, A; Tran, C JOURNAL OF LOW TEMPERATURE PHYSICS 184(1-2), pp.486-491, JUL 2016

2. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY2016. 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
FY2016	0	0	0	0	0
	12	4	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
FY2016	0	0	0	0	0
	8	7	1	0	16

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
FY2016					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2016					

World Premier International Research Center Initiative (WPI)
Appendix 5 FY 2016 Visit Records of World Top-caliber Researchers from Abroad

Researchers Total: 17

	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	Robert Williams	76	Astronomer, emeritus, Space Telescope Science Institute	Ph.D. Astronomy	Beatrice M. Tinsley Prize (1998) NASA Distinguished Public Service Medal (1999) Karl Schwarzschild Medal (2016)	16/05/11	Colloquium speaker
2	John Carlstrom	59	Professor, Department of Astronomy and Astrophysics, and physics, University of Chicago	Ph.D. Physics	MacArthur Fellos (1998) Magellanic Gold Medal (2004) Gruber Prize in Cosmology (2015)	2016/5/12 - 2016/5/13	Seminar speaker
3	Houjun Mo		Professor, U Massachusetts	Ph.D. Astrophysics	American Publishers Awards for Professional and Scholarly Excellence (2011) Master Chair Professor, University of Science & Technology of China	2016/10/23 - 2016/10/29	Giving Lectures
4	Jason X Prochaska		Professor, Astron&Astrophys s Department, UC Santa Cruz	Ph.D. Astronomy		2016/8/29 - 2016/9/2	Colloquium speaker
5	Tommaso Treu		Professor, Department of Physics and Astronomy, UCLA	2010	American Astronomical Society Newton Lacy Pierce Prize (2010)	2016/10/17 - 2016/10/21	Colloquium speaker
6	Alexander Heger		Director, Monash Center for Astrophysics, Nonash University	Ph.D. Astronomy	Fellow of the American Physical Society (2010-) Council of Graduate Students Outstanding Faculty Award (2010)	2017/1/8 - 2017/1/21	Colloquium speaker
7	Young-Kee Kim	54	Louis Block professor, University of Chicago	Ph.D. Physics	Ho-Am Prize (2005) South Korean government Science/Education Service Medal (2008) Rochester Distinguished Scholar Medal (2010) AAAS fellow (2012-) Leadership Award, Women in Science, Chicago Council of Science and Technology (2012)	2016/8/19 - 2016/8/23	Participation in External Advisory Committee
8	Michel Gonin		Professor, physics at Ecole Polytechnique, director researcher, CNRS	Ph.D. Physics		2017/2/13 - 2017/2/15	Participation in Workshop
9	Matias Zaldarriaga	45	Professor of astrophysics, Institute for Advanced Study	Ph.D. Physics	Helen B. Warner Prize (2003) Gribov Medal (2005) MacArthur Fellowship (2006)	2016/6/11 - 2016/6/17	Short-term stay for joint research
10	Alan Weinstein	73	UC Berkeley (professor, mathematics)	Ph.D, Mathematics	Fellow of the American Mathematical Society (2012)	2016/4/7 - 2016/4/18	Short-term stay for joint research
11	Massimo Porrati	55	Professor, New York University		one of authors for a well-known modified gravity model "DGP model"	2016/6/15 - 2016/7/11	Seminar speaker
12	Nigel Smith		Director at SNOLAB, Adjunct Professor of Laurentian University, Adjunct Professor of Queen's University	Ph.D. Astrophysics		2016/8/21 - 2016/8/23	Participation in External Advisory Committee

13	Steven Kahn	61	Cassius Lamb Kirk Professor in the Natural Sciences, Stanford U & SLAC	Ph.D. Cosmology	Fellow of the American Physical Society (1991-) Member of the American Academy of Arts and Sciences (2012-)	2016/8/21 - 2016/8/23	Participation in External Advisory Committee
14	John Ellis	70	Clerk Maxwell Professor of Theoretical Physics, King's College London	Ph.D. Theoretical Particle Physics	Maxwell Medal and Prize (1982) Paul Dirac Medal and prize (2005) Fellow of the Royal Society of London (since 1985) Fellow of the Institute of Physics (since 1991) Commander of the Order of the British Empire (2012)	2016/8/21 - 2016/8/23	Participation in External Advisory Committee
15	David R. Morrison	61	Professor, UC Santa Barbara	Ph.D. Mathematics	Fellow of the American Mathematical Society (2013-) Fellow of the American Physical Society (2014-) Member of the American Academy of Arts and Sciences (2015-)	2016/8/21 - 2016/8/26	Participation in External Advisory Committee
16	Xiaohui Fan	45	Professor, University of Arizona	Ph.D. Astronomy	Newton Lacy Pierce Prize (2003) Guggenheim Fellowship (2008)	2016/8/22 - 2016/8/27	Participation in Workshop
17	Michael Strauss	55	Professor, Department of Astrophysical Sciences, Princeton University	Ph.D. Physics	Newton Lacy Pierce Prize (1996)	2016/8/23 - 2016/8/27	Participation in Workshop

World Premier International Research Center Initiative (WPI) Appendix 6 FY2016 State of Outreach Activities

Using the table below, show the achievements of the Center's outreach activities in FY2016(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 FY2016 resulting from press releases and reporting.

Activities	FY2016(number of activities, times held)
PR brochure, pamphlet	11
Lectures, seminars for general public	10
Teaching, experiments, training for elementary, secondary and high school students	3
Science café	6
Open houses	1
Participating, exhibiting in events	3
Press releases	25

<Special Achievements>

Careers event for female undergrad and graduate students of departments of physics held

On November 19, 2016, the Kavli IPMU, the Institute for Solid State Physics, and the Institute for Cosmic Ray Research co-organized an event: "I love Physics, After All: Career Advancement for Women Graduates." Aimed at undergraduate and graduate female students of physics, the event provided an opportunity for career guidance and networking among participants, and showcased the attraction of physics. Inspired by the Conferences for Undergraduate Women in Physics (CUWiP) of the American Physical Society, a number of women speakers with advance degrees in physics were invited (from academia, business, and an editorial company) to the event. They spoke about their diverse experiences and career paths after studying physics—including experience overseas, in research, and balancing work and family life. In addition to a tour of the institutes, attendees were able to network and engage in an exchange of views.

Collaborating with other fields—Fusion of Science and Art

Emerging media artist Norimichi Hirakawa participated in Kavli IPMU's Artist-in-Residence (AIR) program in fiscal 2016, the second artist to take part in the program that was established in fiscal 2015. The AIR program allows artists to reside at the institute for a set period, interact with researchers, and showcase their considered experience as artworks to the public. Some of the works emanating from the 2016 AIR are as follows:

- 1) Introduction of the AIR program at the 38th International Conference on High Energy Physics (ICHEP)
- 2) Exhibition featuring Mr. Hirakawa's work and a guest appearance with a researcher during "Science Onsen (Hot Spring)"—a public event at the Kashiwa open campus
- 3) Exhibition and public events at the Yutaka Kikutake Gallery, Toyota Municipal Museum of Art, and at the 2017 Sapporo International Art Festival

Collaborating with other fields—Fusion of Science and Philosophy

On January 22, 2017, the Kavli IPMU and the Tokyo Institute of Technology's Earth-Life Science Institute held their 2nd joint public lecture, titled "A Question of Origins." With the origin of the Universe, Earth, and Life as themes, scientists and a philosopher specializing in each theme were invited to give presentations and explore connections between their fields, including Professor Noburu Notomi, an ancient Greek philosophy expert from the University of Tokyo's Humanities and Social Sciences department.

Collaborating with other fields—Fusion of Science, Art, and Philosophy

On March 25, the Kavli IPMU invited experts in physics, mathematical philosophy, brain science, aesthetics, and contemporary art to a workshop—"Art x Science x Philosophy"—in collaboration with the Tamarokuto Science Center. They considered areas of commonality and difference between science, art, and philosophy. While today each field is becoming standardized, they have not described all segments of human intelligence or sensibilities. At the event, participants tried to identify those elements in these three areas of research that are still missing. The long-form format allowed participants to engage in deep and prolonged discussion.

Kavli IPMU Researcher helps make Planetarium Program

On April 20, 2016, a 3D, full-dome movie—"The Man from the 9 Dimensions"—which has as its Science Advisor Kavli IPMU Principal Investigator Hiroshi Ooguri, was released at the National Museum of Emerging Science and Innovation (Miraikan). The prize-winning movie is inspired by string theory and has received a positive reception—more than 95,000 people have already seen it at the Miraikan, and it has been viewed in Greece, Poland, and the United States. Awards: International Planetarium Society (IPS) Full Dome Festival Best Educational Production Award, Advanced Imaging Society Good Practice Award 2016, and VFX-Japan Award 2017 in the visual effects category.

NHK documentary: "Hitoshi Murayama's Great Adventures in the Universe – Where did we come from?"

Japanese science documentary special "Cosmic Front NEXT: Hitoshi Murayama's Great Adventures in the Universe – Where did we come from?" was presented by Kavli IPMU director Hitoshi Murayama and aired on NHK on Jan 6, and again as a two-part extended version on NHK BS on Feb 9 and 16. Based on popular demand, the first one was rerun on Feb 5, and latter two in digest versions on March 30 and 31. He was also featured on Fuji BS Galileo-X discussing mystery of vanished anti-matter, and on NHK radio show on Jan 10.

Cosmic Front☆NEXT: Planetarium Version—"In Search of Dark Matter"

On January 14, 2017, Cosmic Front☆NEXT: Planetarium Version—"In Search of Dark Matter" was released at the Cosmo Planetarium in Shibuya, Tokyo. The movie introduces the facilities being used to observe Dark Matter. Kavli IPMU Professor Naoki Yoshida makes an appearance, and parts of the program were made with the support of the institute.

Social Network Service (SNS) Usage

• Facebook

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

In 2016, 102 articles related to the Kavli IPMU were posted on the Kavli IPMU wall. In most cases, posts were read by more than 1000 users. The May 11 post announcing Project Researcher Teppei Okumura and Project Assistant Professor Chiaki Hikage's research, "New test by deepest galaxy map finds Einstein's theory stands true", was read by 10,820 users and received 219 likes. (Note: The most read post of FY 2016 recorded 17,376 reads, and was posted on October 6 to promote the Kavli IPMU/Institute for Solid State Physics/Institute for Cosmic Ray Research event for women in science "I love Physics, After All: Career Advancement for Women Graduates")

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

• Twitter

- PI Hiroshi Ooguri (account name: PlanckScale), <https://twitter.com/PlanckScale> (since September 2009)

- Director Hitoshi Murayama (account name: sleptogenesis), <https://twitter.com/sleptogenesis> (since January 2010)

• Blog

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

General public books published in FY2016

"Neutrino: Small Discovery. Climbing the stairs to a Nobel Prize in Physics (ニュートリノ 小さな大発見: ノーベル物理学賞への階段)" by Takeaki Kajita

Published June 2016, Asahi Shimbun Publications Inc., 5,000 copies published

"Pursuit of Truth: Dialogue between Buddhism and Astrophysics (真理の探究 仏教と宇宙物理学の対話)" by Hiroshi Ooguri, Shizuka Sasaki

Published November 2016, Gentosha Inc., 11,000 copies published

"Kamiokande and Neutrinos (カミオカンデとニュートリノ)" Supervised by Astuto Suzuki, by Masayuki Nakahata

Published June 2016, Maruzen Publishing Co. (Published copies confidential)

Note: Kavli IPMU PIs K. Inoue, T. Kajita, Y. Suzuki, M. Nakahata, and Kavli IPMU affiliate member T. Nakaya have written several chapters.

Ongoing bestsellers

"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., 147,000 copies published

Note: Korean version published November 2013, Mandarin version published November 2015

"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., 109,600 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., 71,400 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., 43,000 copies published

Note: This book received the 30th Kodansha Prize for Science Books in September 2014. Mandarin version published January 2015, and has since printed 16,000 copies.

"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

Note: Mandarin version published May 2016

"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

World Premier International Research Center Initiative (WPI)
Appendix 7 FY 2016 List of Project's Media Coverage

	Date	Types of Media (e.g., newspaper, television)	Description
1	26/04/2016	Newton (science magazine)	Professor Hiroshi Ooguri talks about The Man from the 9 Dimensions, a visual spectacle of the Theory of Everything, and delves into the world of frontline modern physics. * This article is about the planetarium movie "The Man from the 9 Dimensions" supervised by PI Hiroshi Ooguri.
2	03/05/2016	Chunichi Shimbun (newspaper)	"69th Chunichi Cultural Award recipients named" * This article announces PI Hiroshi Ooguri and PI Takaaki Kajita as award recipients.
3	11/05/2016, 12/05/2016	Phys.org, Science Daily, Astronomy Now, Science Newslines (websites)	"New test by deepest galaxy map finds Einstein's theory stands true", "Daily, New test by deepest galaxy map finds Einstein's theory stands true", "Now, Deepest 3-D galaxy map suggests Einstein's theory stands true by Astronomy Now". Other articles have been published in India, Spain, Maldives, and Nepal. * Project Researcher Teppei Okumura and Project Assistant Professor Chiaki Hikage
4	11/05/2016	The Nikkei (newspaper)	"Opening the door to a Global Age - Kavli IPMU drives world-leading astronomical observation" * This story introduces the Sumire Project's Hyper Supreme-Cam (HSC) and Prime Focus Spectrograph (PFS). Includes comments from Director Hitoshi Murayama, Professor Masahiro Takada, Project Assistant Professor Naoyuki Tamura.
5	12/05/2016	MyNavi News, goo news, Excite News (websites)	"New test by deepest galaxy map finds Einstein's theory stands true - Kavli IPMU" * Research news articles featuring Project Researcher Teppei Okumura and Project Assistant Professor Chiaki Hikage.
6	26/05/2016, 27/05/2016	Mainichi Shimbun (newspaper), Mainichi Shimbun (website), Asahi Shimbun (website)	"Black hole interferes with star formation", "Hot gas winds interfere with star formation", "AKIRA's hot gas explains mechanism behind how star formation stops" * Project Researcher Edmond Cheung and Project Assistant Professor Kevin Bundy
7	26/05/2016, 27/05/2016	Phys.org, Nature Publishing, International Business Times UK, and others (websites)	"Supermassive Black Holes in 'Red Geyser' Galaxies Cause Galactic Warming", "Red geysers: How supermassive black holes turn galaxies into featureless wastelands by Hannah Osborne" Other articles have been published in Australia, India, Spain and Georgia. * Research news articles featuring Project Researcher Edmond Cheung and Project Assistant Professor Kevin Bundy
8	28/05/2016	Yahoo! News Japan, MSN Japan (websites)	"AKIRA's super hot gas explains how to stop star formation" * Project Researcher Edmond Cheung and Project Assistant Professor Kevin Bundy
9	17/06/2016	Science Newslines, Before It's News, and others (websites)	"Scientists Detect Most Distant Signs of Oxygen in the Universe", "Oxygen found in one of the universe's most distant galaxies" * Research news article about Osaka Sangyo University Associate Professor Akio Inoue's project, which involves Project Professor Naoki Yoshida
10	25/06/2016	Newton (science magazine)	Naoshi Sugiyama talks about the large-scale structure of the Universe * PI Naoshi Sugiyama provides expertise in this article
11	25/06/2016	Newton (science magazine)	"Einstein's theory stands true even in the depths of the Universe" * Research news article featuring Project Researcher Teppei Okumura and Project Assistant Professor Chiaki Hikage
12	12/07/2016, 13/07/2016	Phys.org, Sciencemag, Science Daily, Science Newslines, and others (websites)	"Blue is an indicator of first star's supernova explosions", "Blue is an indicator of first star's supernova" * Research news article featuring Project Researcher Alexey Tolstov, PI Ken'ichi Nomoto, and Project Researcher Miho Ishigaki
13	15/07/2016	AstroArts (website)	"Blue is an indicator of first star's supernova" * Research news article featuring Project Researcher Alexey Tolstov, PI Ken'ichi Nomoto, and Project Researcher Miho Ishigaki
14	10/08/2016	Phys.org (website)	"Investigating the Neutrino Mass Scale with the ultra-low background KamLAND-Zen detector" * Research news article featuring KamLAND-Zen experiment lead by PI Kunio Inoue, and involving Project Assistant Professor Alexandre Kozlov
15	14/09/2016	Courier Japan (website)	"Simply being alive doesn't inspire new ideas about how to break down walls, but science does" Special talk about the future by those working at the intersection of Art and Science * Project Researcher Ryo Namba talks part of a group discussion
16	26/10/2016	Yomiuri Shimbun (newspaper)	"Nobel prize recipient forum. A message for future generations. The Universe: Full of mystery, so many things to find" * Symposium featuring Director Hitoshi Murayama and PI Takaaki Kajita

17	25/11/2016	Nikkei Science (science magazine)	"Unraveling Holography entanglement entropy and the Ryu-Takayanagi formula" * PI Hiroshi Ooguri and Visiting Senior Scientist Tadashi Takayanagi provides expertise in this article
18	28/11/2016	AstroArts (website)	"Superluminous supernovae shines 100 times brighter than usual supernovae" * Research news article featuring Visiting Senior Scientist Sergei Blinnikov, PI Ken'ichi Nomoto, and Project Researcher Alexey Tolstov
19	28/11/2016	Phys.org, e! Science News, IFL Science, and others (websites)	"Violent collision of massive supernova with surrounding gas powers superluminous supernovae", "How The Brightest Supernovae Become Superluminous" * Research news article featuring Visiting Senior Scientist Sergei Blinnikov, PI Ken'ichi Nomoto, and Project Researcher Alexey Tolstov
20	07/12/2016	Nikkei Sangyo Shimbun (newspaper)	"Nara Women's University establishes Kiyoshi Oka Award, first award given to UTokyo Professor Kyoji Saito in theoretical work on geometry" * Award news article featuring PI Kyoji Saito
21	20/12/2016, 21/12/2016	Science Daily, SPACE DAILY, Science Newline, Health Medicine Network, and others (websites)	"First look at birthplaces of most current stars", "VLA, ALMA team up to give first look at birthplaces of most current stars" * Research news article featuring Project Researcher Wiphu Rujopakarn
22	01/01/2017	Physics Today (magazine, website)	"Despite financial squeeze, Japan continues drive to globalize its science enterprise" * Article introduces WPI program and research institutes. Director Hitoshi Murayama provides comment
23	06/01/2017	NHK documentary (NHK TV)	"Hitoshi Murayama's Great Adventures in the Universe: Where are we going?" * Director Hitoshi Murayama features as show guide
24	10/01/2017	Sakiyomi Evening News (NHK radio)	"New Year's Interview (4) Challenging the mystery of the Universe" * Features Director Hitoshi Murayama
25	21/01/2017, 28/01/2017	Yume Yume Engine! (TBS radio)	"Einstein is the scientist that made GPS possible", "Why is the night sky dark? It's to do with the Big Bang" * PI Hiroshi Ooguri makes a guest appearance on both shows
26	26/01/2017	Mainichi Shimbun (newspaper), Mainichi Shimbun (newspaper, Osaka version)	"Forest of Science = Dark matter in the Universe. Captured. Indirect evidence exists, but it's identity remains unknown" * Associate Professor Shigeki Matsumoto provides comment
27	27/01/2017, 28/01/2017	Science Daily, SciNEWS, Publicnow, Health Medicine Network, and others (websites)	"Cosmic lenses support finding on faster than expected expansion of the universe", "Astronomers Use Gravitational Lensing to Measure Hubble Constant", "Astronomers Measure Universe Expansion, Get Hints of 'New Physics'" * Research news article featuring international collaboration H0LiCOW and team member Project Researcher Alessandro Sonnenfeld
28	30/01/2017	AstroArts (website)	"Faster-Than-Expected Expansion of the Universe Supported by Results from Cosmic Lensing Research" * Research news article featuring international collaboration H0LiCOW and team member Project Researcher Alessandro Sonnenfeld
29	08/02/2017	The Japan Times (website)	"'Otaku' gather to celebrate the obsessive at Nerd Nite Tokyo" * Article on Nerd Nite Tokyo featuring Project Researcher Anupreeta More
30	09/02/2017, 16/02/2017	Cosmic Front NEXT (NHK BS TV)	"Hitoshi Murayama's Great Adventures in the Universe: Where are we going?", "Hitoshi Murayama's Great Adventures in the Universe: Where are we going?" * Hitoshi Murayama features as a show guide in the two-part extended program of the NHK documentary that had aired on 06/01/2016
31	12/02/2017	Galileo X (TV BS Fuji)	"The 'antimatter' that vanished. Why do we exist?" * Guest appearance by Director Hitoshi Murayama, PI Kunio Inoue. Director Murayama provides explanation of antimatter, also features T2K and KamLAND-Zen experiments
32	19/02/2017, 21/03/2017	UNESCO Creative Cities Network, culture360 (websites)	"Datum" by Norimichi Hirakawa: a glimpse of 2017 Sapporo International Art Festival, Wrocław Everything and Nothing exhibition * Article introducing group talk "Media Art: Art and Science" at the 2017 Sapporo International Art Festival featuring Kavli IPMU Artist in Residence Norimichi Hirakawa
33	01/03/2017, 02/03/2017	Science Portal, MyNavi News (websites)	"First public release of gigantic galaxy data captured by Subaru Telescope", "Hyper Supreme-Cam (HSC) releases observational data" * Articles on the first public data release from HSC as part of the Subaru Strategic Program
34	08/03/2017, 11/03/2017	Science Newline, Science Daily, News Café, and others (websites)	"First Public Data Released by Hyper Supreme-cam (HSC) Subaru Strategic Program", "First public data released by hyper supreme-cam Subaru Strategic Program" * Articles on the first public data release from HSC as part of the Subaru Strategic Program