

World Premier International Research Center Initiative (WPI)

FY 2019 WPI Project Progress Report

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Common instructions:

- * Unless otherwise specified, prepare this report based on the current (31 March 2020) situation of your WPI center.
- * So as to execute this fiscal year's follow-up review on the "last" center project plan, prepare this report based on it.
- * Use yen (¥) when writing monetary amounts in the report. If an exchange rate is used to calculate the yen amount, give the rate.
- Prepare this report within 10-20 pages (excluding the appendices, and including Summary of State of WPI Center Project Progress (within 2 pages)).

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

Research Highlights

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

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

The JST CREST project "Statistical Computational Cosmology" led by N. Yoshida is aimed at developing fast imaging data analysis applications for the Subaru Hyper Suprime-Cam (HSC) survey. In 2019, they released a catalog of 1800 supernovae detected by the first HSC transient survey and developed a deep neural network that automatically classifies the detected supernovae into multiple types. Another science project is mass density reconstruction through weak gravitational lensing effect. They have applied a generative adversarial network to HSC16A data and successfully reduce the noise. They aim at performing cosmological parameter inference using the denoised mass maps. They have been awarded the highest score A+ in a final review of the CREST project and will receive further financial support as a JST AIP program in 2020-2022.

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

In vivo and three-dimensional gamma-ray imaging, which enables us to visualize and measure cell activity and biological processes, provides improved and novel methods for the diagnosis and treatment of cancer in the pre-clinical phase. A team led by T. Takahashi performs interdisciplinary activities centered around the development of an advanced hard X-ray and gamma-ray detector. In 2019, they have performed various experiments at the Exploratory Oncology Research and Clinical Trial Center (EPOC) at the National Cancer Center. They have established a method to resolve lines from multiple isotopes using an algorithm developed in X-ray astronomy and thereby individual radiation doses can be accurately quantified in phantom experiments. They have also performed experiments using a very promising radionuclide, ^{211}At , which is used as a new alpha-ray cancer therapy and for cancer diagnostics. They have developed a new slit type collimator made of Tungsten by using 3D printing technology, which covers a large area of $\sim 10\text{ cm}^2$ with high efficiency.

(3) Discover new major frameworks for geometric thinking in mathematics and physics with the derived and noncommutative geometry, such as to unify various types of dualities:

Our mathematicians have advanced a new framework for geometric thinking provided by noncommutative and derived geometry. In particular, Y. Toda used derived moduli spaces to refine the Donaldson-Thomas invariants to certain monoidal categories, thus categorifying several important duality (wall-crossing) phenomena. His work uses earlier work of F. Sala and M. Porta on Cohomological Hall algebras (COHAs) which have become an important tool in the study of wall-crossing. W. Donovan, with M. Wemyss, used noncommutative deformations to describe the derived monodromy on the stringy Kahler moduli space of a flopping curve in a 3-fold. M. Kapranov, with V. Schechtman, related shuffle algebras, appearing in many descriptions of COHAs and wall-crossing, with the Goresky-MacPherson procedure of intersection cohomology extensions of local systems.

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

- The HSC team explored how cosmic large-scale structures evolve as a function of cosmic time using the first two years data and determined the parameter characterizing the clumpiness of the Universe today with the world's highest-level precision. The Prime Focus Spectrograph (PFS) team achieved important milestones for the project including a successful engineering trial of the metrology camera and re-assembling the first spectrograph modules shipped to Hawaii Observatory.

- The Kavli IPMU is directly involved in the analysis of T2K data with M. Hartz serving as co-Analysis Coordinator and our former project researcher B. Quilain as the leader of the Japanese oscillation analysis effort. T2K for the first time measured the phase that governs CP violation with enough significance and the result has been published in Nature Journal.

- Cosmic microwave background (CMB) experiments have been actively led by the Kavli IPMU team. POLARBEAR team released the science papers including the measurement of the large angular scale B-mode to aim the signal band of the primordial B-mode. LiteBIRD has been selected as the JAXA ISAS large class second strategic satellite project and the team accelerates the design study.
- Belle II have finally launched a decade-long operation of collecting e^+e^- collision data using the silicon vertex detector produced in the Kavli IPMU. The first physics paper about searches for a new gauge boson Z' has been accepted for publication in Physical Review Letters.
- EGADS team led by M. Vagins finished preparations of the Super-Kamiokande detector for the addition of gadolinium (Gd), which is expected to start in April 2020.

Scientific research progress

In the calendar year (CY) 2019, 394 papers were published (496 when including WPI-related). Over the past 5 years, we have consistently produced a large number of scientific papers: 315 (452) in CY2014, 349 (466) in CY2015, 353 (450) in CY2016, 306 (392) in CY2017 and 403 (519) in CY2018. Among the WPI papers published in CY2019, the rate of highly cited "top 1% of papers" was 16 (4.1%) based on the Web of Science by Clarivate Analytics. The impact factor for all of our refereed papers published from the institute's inception to Dec 2019 are as follows: the average number of citations per paper is 31.8; 223 papers have over 100 citations and 634 over 50 citations in which review papers are excluded. The fraction of CY2019 papers with international collaboration reached 79%. Kavli IPMU members received 22 valuable prizes/awards and honorary titles in FY2019.

Interdisciplinary studies

In FY2019, the Kavli IPMU held interdisciplinary seminars including 73 math-string (MS) seminars and 87 astronomy-particle physics-experimental physics-cosmology (APEC) seminars among 207 seminars and colloquia (14 seminars were cancelled due to COVID-19). T. Takahashi is a leading astro-particle physicist working in the H.E.S.S. collaboration, which for the first time detected a gamma-ray burst in very-high-energy gamma light and identified very high-energy gamma ray region in Crab Nebula. His collaboration with JAXA/ISAS and Keio University School of Medicine to apply his detector technology to biomedical research completed a successful clinical trial using a newly-developed imaging diagnosis device.

Globalization

The ratio of non-Japanese members among all of researchers employed by the Kavli IPMU is 47%. During FY2019, we had 999 (1245) visitors (the numbers in the parentheses count multiple visits), 463 (555) of which were international. We hosted 18 international conferences and workshops (2 conferences cancelled due to COVID-19 have been excluded), where 430 were from foreign institutions among 1424 participants. K. Martens has been appointed the first Director of the Kamioka-branch, which demonstrates the fact that the Kavli IPMU has established a truly international environment and support system. The Kavli IPMU signed 24 cooperative research agreements or memoranda of understanding (MOU) including a new research agreement with the University of Bonn in 2019. Based on the agreement with the Department of Physics at the University of Oxford for the Kavli IPMU Oxford D.Phil. Fellowships, we accepted eight students from the University of Oxford and three have defended their Ph.D. theses.

Organizational Reform

Our successful system reforms have spread across the University. The number of cross-appointments initiated at the Kavli IPMU has reached 128 in UTokyo. Our system reforms have also spread to other research institutions, such as ones between Kyoto University and MPI, and between KEK and Osaka University. Together with ISSP and the UTokyo Physics Department, we have established an "International Institute for Quantum Science," a multi-divisional organization within UTokyo. The new graduate program coordinated by H. Murayama has been approved as a JSPS WISE Program (Doctoral Program for World-leading Innovative & Smart Education). This program will give us a leverage that more Kavli IPMU faculty members can directly supervise graduate students.

Efforts to Secure the Center's Future Development over the Mid- to Long-term

Through an initiative by H. Ooguri, the long term strategic planning committee set three top priorities in the upcoming 10 years: astronomical survey projects including HSC, PFS, and LSST and WFIRST as future projects; CMB projects including Simons Observatory and LiteBIRD; and Kamioka projects including SK-Gd, T2K, and Hyper-Kamiokande. In addition, two initiatives are recommended: Data Analysis initiative and Tabletop Dark Matter experiments. These recommendations guide our funding and hiring priorities in coming years. Diversity initiatives were further developed. A Code of conduct for members and visitors has been documented and posted on our home page. Implicit bias training was conducted and harassment training was revised. Hiring and recruitment practices were reviewed, and their rules were documented. A weekly women's lunch has started to regularly meet and talk freely together. The President of UTokyo has directed its Diversity Office of the Central Administration to spread our diversity initiatives throughout the university.

Others

H. Ooguri was conferred the 2019 Medal of Honor with Purple Ribbon by the Emperor of Japan for his contribution to theory of elementary physics. The Kavli Foundation news section reported on four research projects in the Kavli IPMU. The Elegant Mathematics exhibition developed by Y. Ito to explore the beauty and role of mathematics in everyday life was held at the Kashiwa Library of UTokyo. "The Man From the 9 Dimensions" movie supervised by H. Ooguri made its debut in Germany. Our "Ask A Scientist" video series continues to attract viewers. H. Ooguri made a guest appearance on popular TV show "Chiko-chan's Don't Sleep Through Life" to explain what gravity is to a general audience. Kavli IPMU hosted 8th WPI Science Symposium "The Power of Mathematics: Bridging Worlds Together" where more than 480 people gathered.

- * Describe clearly and concisely the progress being made by the WPI center project from the viewpoints below.
- In addressing the below-listed 1-6 viewpoints, 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 disciplines).
 - (2) Whether a proactive effort continues to be made to establish itself as a “truly” world premier international research center.
 - (3) Whether a steadfast effort is being made to secure the center’s future development over the mid- to long-term.

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

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

We will achieve these goals building on the initial success by

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

Concerning the system reform, we take up the challenge to

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

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

1. Advancing Research of the Highest Global Level

- * Among the research results achieved by the center, concretely describe those that are at the world’s highest level. In Appendix 1, list the center’s research papers published in 2019.
- * Regarding the criteria used when evaluating the world level of center, note any updated results using your previous evaluation criteria and methods or any improvements you have made to those criteria and methods.

The Kavli IPMU aims at establishing a multi-disciplinary research institute with the unifying goal of understanding five fundamental questions about the Universe: how it started, what it is made of, what its fate is, what its fundamental laws are, and why we exist in it. We proposed to address these questions from the synergistic perspectives of physics, mathematics, experimental physics, and astronomy. Below we describe the research progress in 2019 related to each question.

How did the Universe start?

Early Universe: There has been a growing interest in studying both theoretical and observational implications of cosmological gravitational wave backgrounds. R. G. Cai, S. Pi, and M. Sasaki discovered that, under a reasonable assumption, cosmological gravitational waves generated from a certain source at some epoch in the early Universe exhibit a universal scaling behavior in the infrared limit, independent of the source. E. Cotner, A. Kusenko, M. Sasaki and V. Takhistov made an interesting observation that if Q-ball-like meta-stable objects dominated the Universe for a certain period of time in the early Universe, their clusters may have formed primordial black holes which may either be identified as dark matter of the Universe or be detected by near-future gravitational lensing experiments.

CMB experiments: Four faculty members, 6 postdocs, and 9 visiting students have actively led the POLARBEAR2, Simons Observatory, and LiteBIRD. POLARBEAR team released science papers, including the measurement of the large angular scale B-mode, which aims the signal band of the primordial B-mode. They also released the first analysis using the de-lensing method from the POLARBEAR data and the instrumental performance paper of PB2 (spectral calibration by F. Matsuda and the deployment status by D. Kaneko) to remove the contribution from the weak gravitational lensing B-mode. The ice cloud effect in the stratospheric layer is identified by S. Takakura as the potential source of the systematic effect. A dedicated infrared camera for a constant monitoring and the POLARBEAR2 receiver are now installed on the telescope at Atacama, Chile. It is under the commissioning phase and the data analysis is in progress. The Simons Observatory Japan team is in charge of the development of the cryogenically cooled optics system of the small aperture telescopes. They completed the optical and mechanical designs, and the fabrication and testing are in progress. The first assembled optics tube is scheduled to be delivered to the collaborator in the USA, and it will be integrated to the rest of the receiver system this year. Finally, LiteBIRD has now been selected as the JAXA ISAS large class second strategic satellite project. Now LiteBIRD becomes the only space agency selected CMB B-mode satellite project in the world, and the team, including the international collaborators, accelerates the design study (H. Sugai et al., *Journal of Low Temperature Physics*, in press). K. Nakamura now joins the CMB team in the Kavli IPMU with his background from neutrino physics. S. Stever, who was a project researcher in the Kavli IPMU, moved to Okayama University as a tenure track assistant professor [(4) of 9 challenges].

What is the Universe made of?

Particle phenomenology: Many researches in particle phenomenology in FY2019 concern the diverse study of dark matter. For instance, S. Matsumoto and T. Poyen comprehensively studied a light thermal dark matter associated with a light scalar mediator and found that future lepton colliders will play a significant role to explore uncharted parameter regions (JHEP1907, 050, 2019). H. Fukuda and S. Shirai proposed a new idea of dark matter search using a soft micro-displaced track in collaboration with LHC experimentalists (PRL124, 101801, 2020). Y. Stadnik, working together with the RIKEN-led BASE collaboration, conducted a search for ultra-low-mass axion-like dark matter using state-of-the-art antiproton measurements at CERN, improving over astrophysical bounds by up to five orders of magnitude (Nature575, 310, 2019). I. Saha, working together with T. Katayose, S. Matsumoto and S. Shirai, have explored the fermionic Z-portal dark matter model, and shown that it is accessible at the future lepton colliders, such as ILC and CEPC, with better precision than current direct dark matter detections (PRD101, 015007, 2020). N. Barrie, S. Ge and T. T. Yanagida proposed a flavor mixing model for the Standard Model fermions based on a broken democracy mixing pattern, which can successfully explain their observed mixing properties and masses, while also providing unique predictions for neutrino-less double beta decay (PLB801, 135159, 2020).

T. Melia uncovered novel features in the way light Dark Matter — with mass less than 1 MeV — interacts with proposed detector materials (e.g. crystals or molecules). In this mass region, the de Broglie wavelength of the Dark Matter is longer than typical interatomic spacings, and its interactions are described by an effective field theory using the collective modes (phonons) of the detector. There is a curious feature of the Dark Matter-phonon coupling (PRD100, no.5, 055011), where a cancellation occurs such that the leading interaction term vanishes, with the implication that higher order terms must be calculated. T. Melia studied further details of such higher order, multi-phonon excitations in crystal detectors (PRD101, no.3, 036006). T. Melia also continued his research into using chemical crystals to detect dark matter, with a preprint appearing that demonstrated a proposed ‘magnetic avalanche’ Dark Matter detection mechanism (arXiv:2002.09409).

XENONnT: The XENONnT WIMP dark matter detector is being commissioned at the Laboratori Nazionali del Gran Sasso in Italy. Two Kakenhi grants support the effort at the Kavli IPMU: Grant-in-Aid for Scientific Research A (Kiban A) for the neutron veto, a new addition to the experiment based on ideas by M. Vagins, and first implemented and further developed at EGADS at the Kamioka Observatory. The actual installation of the neutron veto at LNGS will start as soon as the corona virus outbreak allows. The second grant is a Bilateral Research grant with the PI of the German XENON collaborators at the University of Münster. This grant aims to develop a new method to

concentrate radon in the liquid xenon by drifting the charged radon impurities through the liquid. This is expected to boost the Münster group's radon removal distillation column's efficiency. Field Emitter Arrays were obtained that will first be tested for their charge injection properties and later used to see if radon can indeed be charged and drifted in the liquid xenon. K. Martens is the principal investigator for both grants; within the collaboration K. Martens serves on the collaboration's Collaboration Board, and became an elected member of its Editorial Board and Public Relations Team. Data taking with XENONnT is scheduled to start in 2020. Through close collaboration with Kavli IPMU affiliated members at ICRR's Kamioka Observatory, and among these in particular S. Moriyama, they also have access to S. Moriyama's grant (Grant-in-Aid for the Scientific Research on Innovative Areas) that supports the procurement of radiopure gadolinium sulfate for the neutron veto. With Kavli IPMU affiliate M. Yamashita (ICRR) as his Co-PI, S. Moriyama also leads a Kiban A grant dedicated to liquid xenon purification in XENONnT. S. Moriyama's student is getting ready to delve into XENONnT data analysis once data taking has started [(4) of 9 challenges].

What is the fate of the Universe?

SuMIRe (HSC and PFS): SuMIRe (Subaru Measurement of Image and Redshifts) is an international astronomy/astrophysics project aimed at uncovering the origin and future of the universe, led by the Kavli IPMU. One of the two subprojects of SuMIRe is carrying out a wide-field imaging survey of the universe with the Subaru Hyper Suprime-Cam (HSC) and promoting scientific opportunities with the unique dataset being taken so far. The international team, led by Kavli IPMU members C. Hikage and M. Oguri, used multi-color data from the first two years over 137 sq. deg. of the HSC survey to carry out a high-precision measurement of cosmic weak lensing power spectra [PASJ, 71, 43 (2019)]. The team used the measurements to explore how cosmic large-scale structures evolve as a function of cosmic time, and then determined the parameter $S_8=0.800^{+0.029}_{-0.028}$ to about 3.6% fractional precision that characterizes clumpiness of the Universe today. Compared to Planck cosmic microwave background constraints, their results prefer slightly lower value of S_8 similarly to what have been indicated by other weak lensing experiments such as Dark Energy Survey in US and Kilo-Degree Survey (KiDS) in Europe. This inconsistency might indicate new physics beyond the standard Λ CDM model such as a model involving time-evolving dark energy.

As a part of HSC survey, a transient survey has been conducted on one of the deep fields of the survey. The field has been covered by 5 pointings of HSC (effective covered area is 7.5 square degrees) and repeatedly observed over 6 months from 2016 November to 2017 April. This observation has captured more than 1,800 supernova (SN) candidates. Among them about 400 SN candidates are thought to be SN type Ia (SN Ia) which can be used as "standard candle" to measure precise distance to the objects. Fifty-eight of host galaxies of these SN Ia exist beyond 8 billion light years away. At the same distance range about 50 SN Ia has been previously discovered by Hubble Space Telescope by the observation over 10 years. Thanks to the very wide field of view of HSC, HSC observation has doubled the number of distant SN Ia with a half year observation. This data will be used to constrain the nature of dark energy.

On the other hand, we also have made progress in another subproject of SuMIRe, a wide-field multi-object spectrograph, Prime Focus Spectrograph (PFS) project, aimed at making the spectroscopic follow-up observations of distant objects in the Universe. This project is being led by H. Murayama as the principal investigator (PI), the science group co-leader M. Takada, and the project manager N. Tamura, all working at the Kavli IPMU. The PFS project is based on an international collaboration that consists of both physicists and astronomers from the Academia Sinica Institute for Astronomy and Astrophysics (ASIAA, Taiwan), Jet Propulsion Laboratory of NASA, the California Institute for Technology, Princeton University, Johns Hopkins University, Laboratoire d'Astrophysique de Marseille (LAM), Universidad São Paulo, the Laboratório Nacional de Astrofísica (LNA, Brazil), the Max Planck Institutes for Astrophysics, and for Extraterrestrial Physics, the PFS Chinese consortium, the NorthEast Participation Group (NEPG) in US. The construction of the PFS instruments is well underway. During FY2019, we achieved important milestones for the project. First, in Aug 2019 the team carried out a successful engineering trial of one of the key components of PFS, the metrology camera, at the Subaru Telescope site at the 4200m summit of Maunakea in Hawaii. The metrology camera, located at the bottom of the telescope, makes accurate measurements of the positions of the fibers on the prime focus. Secondly, the first spectrograph modules which consist of ten and

several assemblies such as the camera units, grating assemblies and the bench were shipped to Hawaii Observatory, National Astronomical Observatory in Hawaii. On 25 November, the spectrograph modules were successfully re-assembled at the Subaru Telescope site. Kavli IPMU scientist, Y. Moritani, is leading the team to make detailed plans to carry out on-site tests of the performance and on-sky commissioning observations with PFS. Kavli IPMU scientist, K. Yabe, is leading the team to develop software to estimate an expected spectrum of each astronomical object with PFS, as well as to simulate a 360 Subaru-night PFS survey in detail, including the planned science programs. We envision that we can start science operation in 2022, spending more than or equal to 360 nights of Subaru telescope. The combination of HSC and PFS is unique in the world and will enable us to examine the nature of dark matter and dark energy, the evolution and origin of galaxies and the assembly history of the Milky Way, Andromeda Galaxy, and the Local Group as a whole [(4) of 9 challenges].

Intergalactic medium (IGM) and Large-Scale Structure: It was a transitional year for the team led by Kavli IPMU Assistant Professor KG Lee. In January 2020, they carried out the final observations of the COSMOS Lyman-Alpha Mapping and Tomography Observations (CLAMATO) program on the Keck-I telescope in Hawaii. While this is the end of the data collection, science analysis is still underway, especially regarding the analysis of the galaxy/Lyman-alpha forest cross-correlations (by KG Lee), high-redshift cosmic web analysis (by former visiting scholar B. Horowitz, now at Princeton), and constraints on galaxy protocluster pre-heating (by Kavli IPMU Project Researcher R. Kooistra). On a parallel effort, Project Researcher M. Ata has worked on combining all existing high-redshift spectroscopic surveys in the COSMOS field to reconstruct the underlying matter density field at $1.4 < z < 3.5$. This required developing new multi-tracer extensions to BIRTH, the novel Bayesian initial density reconstruction code. These results will allow them to run constrained simulations of the observed $z \sim 2-3$ large-scale structure from primordial times to the present day, which will be a powerful way to study the evolution of galaxy protoclusters. It will also provide a baseline for comparison with the IGM absorption in order to test the fluctuating Gunn-Peterson approximation. New Project Researcher I. Khrykin will also use this map to study whether the IGM thermal properties seen in high-resolution absorption spectra vary as a function of matter density as suggested by exotic models of IGM thermal evolution. In the summer of 2019, the group hosted two summer students from China: Y. Kang (Beijing University) who worked on machine-learning models of IGM absorption, and Y. Huang (USTC) who worked on cosmic web and large-scale structure algorithms.

What are its fundamental laws?

String theory: H. Ooguri worked on aspects of conformal field theories that are relevant to his Swampland program, i.e. the question on how to judge whether a given low energy effective theory with gravity can be realized as an approximation to a consistent quantum theory such as string theory. This program was initiated by C. Vafa in 2005 and H. Ooguri was one of the first contributors to this program. In particular,

- A) With N. Benjamin, S.-H. Shao, and Y. Wang, H. Ooguri used the light-cone bootstrap method to two-dimensional conformal field theories to show that the pure Einstein gravity theory in three-dimensional anti-de Sitter space, as defined by A. Maloney and E. Witten, cannot have a consistent conformal field theory dual. This suggests that the pure 3-dimensional Einstein gravity is in the Swampland. This paper was published in Physical Review D and selected for Editors' Suggestion.
- B) The twist gap is an important concept in conformal field theory with a variety of implications, in particular on its global symmetry. With N. Benjamin, S.-H. Shao, and Y. Wang, H. Ooguri showed that every compact, unitary two-dimensional conformal field theory with an abelian conserved current has vanishing twist gap for charged primary fields with respect to the $u(1) \times$ Virasoro algebra. This means that either the chiral algebra is enhanced by a charged primary field with zero twist or there is an infinite family of charged primary fields that accumulate to zero twist.

H. Ooguri also started a project with M. Dodelson, a postdoc at the Kavli IPMU, to study properties of string theory propagating near a horizon of a black hole. They are interested in exploring possibilities to observe stringy phenomena near black hole horizons. As a preparation for this project,

H. Ooguri and M. Dodelson studied how a particular class of singularities in string theory amplitudes in anti-de Sitter space expected from Landau's argument can be resolved by stringy effects. This has led to a discovery of a new type of bounds of the Mellin transform of correlation functions of conformal field theory. The paper was published in Physical Review D.

S. Shirai and M. Yamazaki constrained a version of the "scalar weak gravity conjecture", motivated by string theory and quantum gravity, from fifth-force searches (arXiv:1904.10577). Moreover, A. Kusenko, V. Takhistov and M. Yamada and M. Yamazaki worked out the cosmological consequences of the scalar weak gravity conjecture, pointing out the implications of the conjecture for Q-balls, primordial black holes and dark matter (arXiv:1908.10930)

Mathematics: M. Kapranov (jointly with V. Schechtman, arXiv:1904.09325) found a relation between braided Hopf algebras and factorizable systems of perverse sheaves on symmetric products of the complex line. In particular, the important algebraic construction of the shuffle algebra due to Nichols and Feigin-Odessky, was interpreted as the topological procedure of intersection cohomology extension. Further, working with V. Schechtman (arXiv:1910.01677), M. Kapranov found a description of perverse sheaves on real hyperplane arrangements in terms of diagrams labelled by cells of a cell decomposition of the underlying stratified space, thus bridging the gap between the topological definition of perverse sheaves and various quiver descriptions. Another step in this general direction was made in arXiv:1909.09793, where an analogous cell decomposition of the symmetric product of the complex line was introduced and studied.

T. Kobayashi developed his mathematical program on global analysis on locally symmetric spaces with indefinite metric. He published with F. Kassel a long paper (90 pages) that determines three ring structures of invariant differential operators on spherical varieties with hidden symmetries, and then proved a theorem of spectral decomposition for the system of "intrinsic" differential operators on "standard quotients" by discontinuous groups (69 pages, arXiv:1912.12601). Furthermore, he published a paper with M. Pevzner which initiates a new line of investigation on "holographic transforms" in branching problems (to appear in Ann Inst Fourier), proved with B. Speh a generalized Gross-Prasad conjecture in automorphic forms in the real rank one setting (arXiv:1907.07994), and gave with Y. Benoist a geometric criterion for the unitary representations on reductive homogeneous spaces to be tempered.

T. Kohno established a theory to extend holonomy representations as functors in higher categories by means of the notion of formal homology connections due to K.-T. Chen. He investigated the theory representations of homotopy path groupoids as higher categories. In particular, in the case of hyperplane arrangements, he gave an explicit description of formal homology connections and studied homotopy 2-types of the complement of hyperplane arrangements.

H. Nakajima generalized the definition of Coulomb branches of quiver gauge theories to the case of valued quivers with Weekes. This generalization gives generalized affine Grassmannian slices for type BCFG, where the original one only gives type ADE. He also proved a conjecture by Á. Gyenge, A. Némethi and B. Szendrői on Euler numbers of Hilbert schemes of points on simple surface singularities.

Y. Toda introduced the notion of categorical DT theories for local surfaces in the paper entitled "Categorical Donaldson-Thomas theory for local surfaces" (arXiv:1907.09076). These are triangulated categories which should reconstruct usual DT invariants on local surfaces, and regarded as gluing of locally defined categories of matrix factorizations. He proposed several wall-crossing formulas of categorical DT theories motivated by d-critical analogue of D/K conjecture in birational geometry. In the sequel paper entitled "Hall-type algebras for categorical Donaldson-Thomas theories on local surfaces" (arXiv:2001.06922), he proved that categorical DT theories admit some Hall-type algebra structures. These algebras categorify BPS algebras which are also important in physics. In particular there is a Hecke action of K-theoretic Hall-algebras of zero dimensional sheaves on surfaces to the K-theoretic Pandharipande-Thomas theory on local surfaces, which may be relevant for categorifications of Gopakumar-Vafa formula of PT theory.

T. Abe constructed trace formalism for 6-functor formalism of motives. This was constructed in order to apply to ramification theory. More precisely, T. Abe constructed certain cycle last year, and in order to extract information about ramification from this complicated cycle, one needs to use 6-functor formalism of Ayoub. In order to achieve this, it is necessary to upgrade the current trace formalism to infinity categorical trace formalism, which is still work in progress.

T. Milanov worked on two projects in FY2019. He finished his joint project with J. Cheng on integrable hierarchies and Gromov–Witten invariants of Fano orbifold lines of type D. They constructed a system of Hirota Bilinear Equations (HBEs) that governs the Gromov–Witten invariants of type D, and they proved that the HBEs parametrize the solutions of an integrable hierarchy which is an extension of an appropriate Kac–Wakimoto hierarchy. Their work is written in two papers both available on arXiv:1910.03150 and 1909.12735. The second project is in collaboration with A. Alexandrov. They have constructed a matrix model of Kontsevich type for the total descendent potential of a simple singularity of type D. Their work will be available on the arXiv soon.

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

Why do we exist?

T2K: The T2K experiment studies neutrino oscillation using beams of neutrinos and antineutrinos produced at the J-PARC accelerator and detected 295 km away in the Super-Kamiokande (SK) detector. T2K compares the rate of muon neutrino to electron neutrino oscillations with the rate of muon antineutrino to electron antineutrino oscillations. A difference in the oscillation rates for these neutrinos and antineutrinos would be evidence of CP violation in the lepton sector. Until now, CP violation has only been observed in quarks. The Kavli IPMU is directly involved in the analysis of T2K data to make neutrino oscillation measurements, with M. Hartz serving as co-Analysis Coordinator, and B. Quilain, who left for a faculty position, serving as the leader of the Japanese oscillation analysis effort. With data collected through May 2018, T2K for the first time made a measurement of the phase that governs CP violation with enough significance to exclude 47% of possible values at 3 standard deviations. This result has been published in Nature Journal (*note: will be published before May*), and M. Hartz was the corresponding author for the paper. 2019 also saw the first successful operation of a new prototype non-destructive proton beam monitor developed for future high-power operation of the beam at J-PARC called the beam-induced fluorescence monitor. This project is a collaboration of researchers at the Kavli IPMU, KEK and Okayama University. T. Vladisavljevic, one of the first joint Oxford/Kavli IPMU graduate students, received his PhD in 2019. L. Cook, who is also a joint Oxford/Kavli IPMU graduate student, is developing atmospheric neutrino production modelling methods that build on techniques used by the T2K experiment. His work is set to play a key role in future neutrino oscillation measurements that combine atmospheric and accelerator neutrino data [(4) of 9 challenges].

Belle II: In a quest for physics beyond the Standard Model of particle physics, the Kavli IPMU is working for the e^+e^- collider experiment Belle II. The Belle II experiment had finally launched a decade-long operation of collecting e^+e^- collision data on March 11th 2019 with all the sub-detectors installed and activated including the silicon vertex detector that the Kavli IPMU team, led by T. Higuchi, mass-produced and delivered to the experiment. Belle II has successfully collected collision data of 10.57 fb^{-1} by the end of 2019. Using the early data, they confirmed an excellent capability of the Belle II detector for the new-physics search by demonstrating good compatibility of the observed $B^0\bar{B}^0$ mixing with Monte-Carlo simulation. The first physics paper, which is on searches for a new gauge boson Z' , has been accepted for publication in Physical Review Letters. Of the variety of physics cases in Belle II, the Kavli IPMU is working on new-physics search in the $B^0\bar{B}^0$ mixing through precise measurements of the CP-violating parameters aiming at the first reports in 2020 [(4) of 9 challenges].

EGADS: In FY2019 the most significant activity for GADZOOKS! was the final preparations of the SK detector for the addition of gadolinium (Gd). This included an additional period of in-tank work involving a remote-controlled submersible that was used to modify piping at the bottom of the water-filled 50-kiloton tank. During this period some above-water piping was also enhanced to allow for

greater total water flow and temperature control. Meanwhile, the Gd-loaded EGADS continues to run as a supernova neutrino detector, serving as a backup during periods of SK maintenance and other downtime, as well as providing Gd-based, realtime alerts to SK shift takers when SK is running. After nearly two decades of R&D since GADZOOKS! was first proposed in 2003, we expect to add the first gadolinium to SK in April 2020 [(4) of 9 challenges].

KamLAND-Zen: Neutrinoless double beta decay is one of the clues to solve the mystery: why is our Universe made of matter? Or why does almost no antimatter exist in our Universe? KamLAND-Zen is an experiment to search for neutrinoless double beta decay in Xenon 136 and its detector is located 1000m underground in the Kamioka mine. An international team led by K. Inoue (PI of the Kavli IPMU and also Director of the Research Center for Neutrino Science, Tohoku University) holds the world best limit for the effective Majorana neutrino mass and the limit excludes most of the degenerated mass hierarchy region. The team has successfully launched new experimental phase with doubled Xenon mass of 745 kg providing more than 3 times enlarged fiducial volume thanks to the new mini-balloon that is 10 times cleaner. The obtained sensitivity has already surpassed the previous phase with much shorter data acquisition period. The combined exclusion region started to overlap with the band region of inverted mass ordering where the theoretical predictions by T. Yanagida's model and K. Hamaguchi's model exist [(4) of 9 challenges].

2. Generating Fused Disciplines

* Describe the content of measures taken by the center to advance research by fusing disciplines. For example, measures that facilitate doing joint research by researchers in differing fields. If any, describe the interdisciplinary research/fused discipline that have resulted from your efforts to generate fused disciplines. You may refer to the research results described concretely in "1. Advancing Research of the Highest Global Level."

Cosmology and statistics: The JST CREST project "Statistical Computational Cosmology" led by N. Yoshida is aimed at developing fast imaging data analysis applications for the Subaru HSC survey. In 2019, they released a catalog of 1800 supernovae detected by the first HSC transient survey conducted in 2016/2017. They have developed a deep neural network that automatically classifies the detected supernovae into multiple types. Another important science project is mass density reconstruction through weak gravitational lensing effect. They have applied a generative adversarial network to HSC16A data and successfully reduce the noise. They aim at performing cosmological parameter inference using the denoised mass maps. In September 2019, they had a final review of the CREST project. The final review came out with a highest score of A+, and they will receive further financial support as a JST AIP program in 2020-2022 [(1) of 9 challenges].

String theory & condensed matter: Y. Tachikawa continued his research on quantum field theories, mainly concerning quantum anomalies, topological phases of matter, and their relevance to string theory. The point is that nontrivial topological phases of matter host anomalous states on their boundaries. One such work is a collaboration with C.-T. Hsieh, a postdoctoral condensed-matter theorist at the Kavli IPMU, and K. Yonekura, an associate professor of Tohoku University who was a postdoctoral member of the Kavli IPMU until a few years ago. In this work, he studied the property of the electromagnetic duality of the Maxwell theory from this point of view, and determined its anomaly and the corresponding topological phase. In another work, in collaboration with J. Kaidi and J. Parra-Martinez, both graduate students at University of California Los Angeles, he revisited the construction of various perturbative string theories, and showed that they can be concisely classified in terms of topological phases on the worldsheet [(3) of 9 challenges].

Physics and mathematics: M. Yamazaki found a rather large class of integrable quantum field theories associated with spectral curves with some defects, starting with a four-dimensional version of the Chern-Simons theory, studied recently by K. Costello, E. Witten and M. Yamazaki. This gives a conceptual explanation of integrability of a large class of two-dimensional integrable quantum field theories, many of which have higher genus spectral curves and seem to be new in the literature (arXiv:1908.02289) [(3) of 9 challenges].

Medical application of gamma-ray imaging: In vivo and three-dimensional gamma-ray imaging, by means of a probe that includes a small amount of radioactive material that emits gamma-rays, plays a key role in providing improved and novel methods for the diagnosis and treatment of cancer in

the pre-clinical phase. It enables us to visualize and measure cell activity and biological processes. Since November 2017, a team led by T. Takahashi has started interdisciplinary activities centered around the development of advanced hard X-ray and gamma-ray detectors that can overcome longstanding obstacles faced by researchers at the cutting-edge of nuclear medicine. In 2019, they have performed various experiments by using their equipment and instruments installed at the Exploratory Oncology Research and Clinical Trial Center (EPOC) at the National Cancer Center. By combining a multi-pinhole collimator with 200- μm diameter pinholes and a 250- μm pitch Cadmium Telluride (CdTe) double sided detector, they have established a method to resolve lines from multiple isotopes using an algorithm developed in X-ray astronomy. By using the method, individual radiation doses can be accurately quantified in phantom experiments. Additionally, they have performed experiments using one very promising radionuclide, ^{211}At , which is being used as a new alpha-ray cancer therapy and for cancer diagnostics. They have developed a new slat type collimator made of Tungsten by using 3D printing technology, which covers a large area of $\sim 10\text{ cm}^2$ with high efficiency [(2) of 9 challenges].

Science and Society: H. Yokoyama, who specializes in modern science theory, and project researcher Y. Ikkatai study gender stereotypes that contribute to fewer women in physics and mathematics by focusing on social norms, images, and cultures. In 2019, they found that parents of female students with inequality were negative towards girls progression to university (Ikkatai et al. 2019) and public with inequality tended to think physics was a male study field (Ikkatai et al. 2020). In addition, they created an “extended model” based on Cheryan’s model (Cheryan et al. 2017) to have a male image for physics and mathematics, and proposed a new model. This new model was tested against English and Japanese data. They also examined what kind of image the word “physics” was composed of and what their masculineness. This research has been promoted as a project of RE-designing Science, Technology and Innovation Policy, SciREX (2017-2020), supported by the Japan Science and Technology Agency (JST) [(2) of 9 challenges].

3. Realizing an International Research Environment

- * Describe what’s been accomplished in the efforts to raise the center’s recognition as a genuine globally visible research institute, along with innovative efforts proactively being taken in accordance with the development stage of the center, including the following points, for example:
 - Efforts being developed based on the analysis of number and state of world-leading, frontline researchers (in Appendix 2); exchanges with overseas entities (in Appendix 4); number and state of visiting researchers (in Appendix 5)
 - 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)

FY 2019 was the third year of the 5-year extension of the WPI support to achieve the proposed 9 challenges. To realize (5) of these challenges, we retained the best and open-minded scientists from around the world. The total number of Principal Investigators (PIs) is 28, among which the number of on-site PIs are 11. All of our 28 PIs (7 non-Japanese: 25%) are world-leading scientists and ensure an international environment for research activities at the Kavli IPMU. H. Ooguri was conferred the 2019 Medal of Honor with Purple Ribbon, which is one of the most prestigious awards in Japan, by the Emperor of Japan for his contribution to theory of elementary physics. This is an honor following the 2018 Hamburg Prize for Theoretical Physics, which was the first year the prize covered all areas of theoretical physics. H. Murayama has been appointed as a University Professor of UTokyo and also Hamamatsu Professor from FY 2019. T. Takahashi is a leading astro-particle physicist working in the H.E.S.S. collaboration, which for the first time detected a gamma-ray burst in very-high-energy gamma light and also identified very high-energy gamma ray region in Crab Nebula in 2019. He has been developing hard X-ray and gamma ray detectors in satellite and rocket experiments and started a new collaboration with JAXA/ISAS and Keio University School of Medicine to apply these detectors to biomedical research. The collaboration completed a successful clinical trial using a newly-developed imaging diagnosis device. On-site PIs in mathematics, M. Kapranov, Y. Toda, and H. Nakajima, are distinguished mathematicians and conduct research as leaders in mathematical studies in algebraic variety, derived category, and gauge theories. M. Vagins has led the EGADS project, and the refurbishment work of the SK detector was successfully completed in January 2019, to apply the concept (SK-Gd). The SK resumed data taking with pure water, and is expecting to collect the world’s first diffuse supernova neutrinos before 2020. M. Takada is the leader of the HSC project, where fruitful scientific results continue to come out following the

publication of the Publications of the Astronomical Society of Japan with 40 papers. Other faculty members also play leading roles in each field and include PIs of big international projects such as Belle II, T2K, KamLAND-Zen, PFS, and LiteBIRD.

K. Martens has been appointed the first Director of the Kamioka-branch. This demonstrates the fact that the Kavli IPMU has established a truly international environment and support system, where a foreign researcher whose first language is not Japanese can take such a leadership role.

A large fraction of our researchers is non-Japanese. Out of 89 faculty members and postdoctoral researchers employed by the Kavli IPMU, 42 (47%) are non-Japanese. During FY 2019, we had 909 (1245) visitors (the numbers in the parentheses count multiple visits). Among them, 463 (555) are international and many of them are world-class scientists. The Kavli IPMU has been keeping its activity as a key hub for exciting intellectual exchange.

The Kavli IPMU hosted 18 international conferences and workshops in a broad range of fields: mathematics, string theory, theoretical astronomy, cosmology, galaxies, high energy physics phenomenology, the Hyper-Kamiokande project, and dark matter experiments. Among 1424 participants in total, 430 were from foreign institutions. Holding conferences in the Kavli IPMU is important to raise our visibility in the international community and to show our leading roles in different fields. Two conferences scheduled in March 2020 were cancelled or postponed due to COVID-19 and not counted above.

Kavli IPMU researchers are mandated to spend 1 to 3 months in overseas institutes. This provides great opportunities for collaborative work, and raises the visibility of the Kavli IPMU achievements. Researchers presented more than 186 invited talks at both overseas and domestic institutions and conferences.

The Kavli IPMU signed 24 cooperative research agreements or memoranda of understanding (MOU), among which 22 include foreign institutes. The agreement, initiated in 2016, with the Department of Physics at the University of Oxford for the purpose of the Kavli IPMU Oxford D.Phil. Fellowships is working effectively. In 2019, one new research agreement was signed with the University of Bonn.

Several doctoral students in astrophysics or particle physics at the University of Oxford are being supervised by faculty members of the Kavli IPMU, and are being provided the opportunity to conduct research in collaboration with Kavli IPMU researchers. So far, we have accepted eight students and three have defended their Ph.D. theses [(7) of 9 challenges]. The Kavli IPMU is also working with another international graduate program in physics (GSGC), which we hope will be extended to astronomy. Young students are becoming attracted to the Kavli IPMU. A group of UTokyo and Kavli IPMU faculty members, including Y. Kawahigashi (representative), T. Kohno, A. Bondal, M. Kapranov, I. Ueda, and Y. Yamazaki, have been planning to submit a proposal for a student exchange program between Hamburg University, entitled "Higher algebraic structures and their concrete", to the JSPS and German Research Foundation (DFG). The proposal includes exchange of several graduate students per year. One of members visited the Hamburg University to discuss the proposal.

We recruit the brightest young people from around the world as postdoctoral researchers and provide them with the best research environment so that they can conduct outstanding research. In the winter of 2019, the Kavli IPMU received 670 applications for our postdoctoral positions including Kavli fellows and newly established KIAA-Kavli IPMU fellows. Nearly 90% of these applications were from abroad. In total, 15 new postdocs will arrive in FY 2020. The Kavli IPMU has been successful in mentoring postdoctoral fellows. Many of our former fellows are now at leading academic institutions. Out of 32 postdocs who left the Kavli IPMU in FY 2019, 9 assumed faculty positions, and 16 moved to other postdoctoral positions in universities or research institutes including Princeton University, Caltech, UC Santa Cruz, Flatiron Institute, University of South Dakota, University of Nebraska-Lincoln, Haverford College, Trinity College Dublin, University of Edinburgh, Università degli Studi di Milano-Bicocca, University of Melbourne, Yonsei University, National Center for Theoretical Sciences in Taiwan, Nagoya University, and Chiba University. A total of 202 (74) postdocs who were hired (those hired by other sources) have left the Kavli IPMU since its establishment in 2007, out of which 96 (24) have assumed faculty positions.

To further raise the Kavli IPMU's profile as a globally visible institute, online science news service such as EurekAlert!, AlphaGalileo and ResearchSEA have been used effectively to publicize our research activities to the world. It was initiated in 2014 and a number of international media coverages jumped from about 20 in 2013 to 318 in 2019.

4. Making Organizational Reforms

- * Describe the system reforms made to the center's research operation and administrative organization, along with their background and results.
- * 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.
- * Describe the center's operation and the host institution's commitment to the system reforms.

A group of Kavli IPMU administrative staff members has been awarded the UTokyo's Special Prize for Business Transformation from the President six times: 2008, 2013, 2015, 2016, 2017 and 2018. The 2008 achievement for developing a "website to accept the foreign researchers in Kashiwa Campus" has already been requested to be adopted by administrative sections of many other faculties. The 2013 "thoroughgoing safety education by network distribution of education video and final quiz" has been requested to be adopted by the UTokyo environmental and safety research center in Kashiwa, Graduate school of Engineering UTokyo, Graduate school of Mathematical Science UTokyo and ICRR. The 2015 "language website to explain UTokyo's employee procedures for international researchers" has been used freely through the UTokyo website. The 2016 "Win-Win project towards University Globalization" has been requested by the UTokyo hospital medical administrative section and ICRR. The 2017 "E-learning for Sexual Harassment Prevention" video in English has been adopted as the official education course of the University Harassment Counseling Center. In 2018, the Kavli IPMU team developed and manages a smartphone app, which provides step-by-step information in English about how to take public transport from the international airport, how to find and ride the free shuttle bus to Kashiwa campus from the train station, and maps that show where individual researcher offices are. This has triggered administrative staff in other departments to start developing their own smartphone apps, further advancing system reforms [(6) of 9 challenges].

The Kavli IPMU has already achieved many reforms, including more flexible uses of tenure positions, merit-based salary system, "nenpo" system for permanent faculty members, Kavli endowment and naming. Our successful system reforms have now spread across the University, and are expected to produce ripple effects to other research institutions to help boost the overall competitiveness of Japan on a global scale. One of the successful ripple effects through the host institute has been cross-appointments. The number of cross-appointments in UTokyo has totaled 128 so far. It was initiated at the Kavli IPMU; in FY 2019, five faculty members continued cross-appointment, H. Ooguri (between Caltech), H. Murayama (Berkeley), N. Yoshida (UTokyo, Physics Dept.), M. Hazumi (KEK), and M. Hartz (TRIUMF). It has now spread over not only within UTokyo, but also to other research institutions, such as ones between Kyoto University and MPI, and between KEK and Osaka University.

Regarding 'taking out walls between departments', H. Yokoyama, Professor in Science Communication and Policy, is acting as a catalyst between the Kavli IPMU and the Interfaculty Initiative in Information Studies by accepting their PhD students. She has been appointed as a research leader of Science Communication of UTokyo Bioethics Collaborative Research Organization which is founded as a collaborative research organization made up of the multiple departments of the UTokyo through the reintegration and arrangement of existing projects, and as a structure to become a hub of social collaboration, education, and research concerning bioethics. Together with ISSP and the UTokyo Physics Department, we have established an "International Institute for Quantum Science," a multi-divisional organization within UTokyo. The LiteBIRD team started to collaborate with a group at the Graduate School of Frontier of Science UTokyo, and also with a group at the Institute for Photon Science and Technology UTokyo, led by President M. Gonokami. We are providing information to the newly established WPI institute, International Research Center for Neurointelligence (IRCN), in UTokyo based on our 12 years of experiences.

The new graduate program, which is coordinated by H. Murayama and involves departments of physics, mathematics, astronomy etc. of UTokyo, has been approved as one of the JSPS WISE Program (Doctoral Program for World-leading Innovative & Smart Education). This program will train graduate students in physics, mathematics, and astronomy for diverse career opportunities. Also, it will give us leverage so more Kavli IPMU faculty members can directly supervise graduate students.

5. Efforts to Secure the Center's Future Development over the Mid- to Long-term

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

The positioning of the Kavli IPMU within UTokyo is quite clear. President Gonokami's 'Vision 2020' emphasizes the importance of "Expansion and Establishment of Internationally-renowned Bases for Research". An action to realize this vision 'Action 2020' has been set up to "establish and expand upon internationally-renowned bases for research at UTokyo 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 UTokyo, and creating new, interdisciplinary knowledge that is the first of its kind in the world." As has already been declared by the President at the WPI Program Committee meeting in recent years, the President recognizes 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 have made the effort to strengthen the University's financial base.

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

A new budget request in the period from FY 2019 to FY 2021 was ranked as No.1 in UTokyo, and funding for the second year has been secured. This budget request is crucial to sustain the Kavli IPMU permanently, and we will make the request for the final year. [(9) of 9 challenges]

Through an initiative by the new Director, the Long-Term Strategic Planning Committee was formed in October 2018 to discuss goals of the Kavli IPMU in the upcoming 10 years, expanding the achievements and current scientific activities of the Kavli IPMU (see below). With 11 meetings including numerous interviews with experts and a symposium, the committee came up with a final report at the end of August 2019. The committee set three top priorities: astronomical survey projects which include HSC, PFS, and possibly LSST and WFIRST as future projects; CMB projects which include Simons Observatory and LiteBIRD; and Kamioka projects which include SK-Gd, T2K, and Hyper-Kamiokande. In addition, two initiatives were recommended: Data Analysis initiative and Tabletop Dark Matter experiments. Belle II and XENONnT projects were deemed important but of lower priorities. These recommendations will guide our funding and hiring priorities in the coming years.

Our scientific projects are making great progress. In astronomical survey projects, HSC, one of the main projects in the Kavli IPMU, led by M. Takada, has performed an analysis based on the first two years data and has made advances in research in many areas of astronomy and physics. Construction of PFS, a powerful tool for spectroscopy, has been in progress. One of the key components, the metrology camera, was confirmed to make accurate measurements during the instrument's onsite trial in August 2019, and we expect to start science operation in 2022. In CMB

projects, LiteBIRD is one of the projects on the MEXT Roadmap in Japan and the master plan of Science Council. The Kavli IPMU team is the main proponent, involved in developing cryogenic detectors and relevant equipment to verify the technical feasibility of LiteBIRD. ISAS/JAXSA has approved the launch of the LiteBIRD satellite in 8 years. In Kamioka projects, the Kavli IPMU has been the key institute of this international collaborative project. The renovation for Gadolinium-doped Super-Kamiokande (SK) project, SK-Gd, was completed in 2018 and data taking resumed at Kamioka with pure water; it is expected to collect some new supernova neutrinos in about two years. Belle II group successfully delivered silicon vertex detectors to the B factory experiment at KEK and has moved on to the data taking/analysis phase. The dark matter research project XMASS has completed data taking, and the team has joined XENONnT project at Gran Sasso in Italy, where the collaboration approved Gadolinium addition, an invention by the Kavli IPMU as mentioned above, to improve neutron veto.

Regarding neutrino experiments, the Kavli IPMU is a part of the new 'Next-generation Neutrino Science Organization' together with ICRR, the UTokyo Faculty of Science and the lately joined Earthquake Research Institute, to advance future experiments for neutrino research. This organization is based on the newly defined category for interdisciplinary research in UTokyo. To make our research directly beneficial to the society, we started a Gamma-ray imaging project for medical research. A new laboratory has been set up at the Kavli IPMU for detector R&D, and an agreement between the Kavli IPMU and National Cancer Center (NCC) was signed. A new laboratory at NCC has started in-vivo imaging experiments of small animals using a variety of radio-isotopes. This research brings advanced technologies of space instruments to bio-medical and drug research, and gives an impact on innovation of cancer research targeting within about three years. Collaboration and stimulation among fields of mathematics and theoretical physics will be strengthened in coming years.

Also, as an initiative of the new Director to achieve an inclusive and supportive environment for increasing diversities, the following new leaders were appointed in FY 2018 (effective on April 1, 2019): H. Yokoyama is the first female member of our Steering Committee; K. Martens is the Director of our Kamioka Branch; A. Kusaka, a researcher at LBNL/UTokyo, is the director of our Berkeley Satellite. In FY2019, diversity initiatives were further developed. A Code of conduct for members and visitors has been documented and posted on home page. Implicit bias training was conducted at the all-hand meeting of Kavli IPMU members and harassment training was revised. Hiring and recruitment practices were reviewed, and their rules were documented. A weekly women's lunch has started to regularly meet and talk freely together. In the workshops hosted by the Kavli IPMU, diversity requirements are explicitly shown on workshop web page. The President of UTokyo has directed its Diversity Office of the Central Administration to spread our diversity initiatives throughout the university, and we are discussing with the Office to implement them.

6. Others

* Describe what was accomplished in the center's outreach activities last year and how the activities have contributed to enhancing the center's "globally visibility." In Appendix 6, describe concretely the contents of these outreach activities. In Appendix 7, describe media reports or coverage, if any, of the activities.

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

In FY 2019, the Kavli IPMU accomplished various outreach activities, including the following which particularly contributed to enhance the globally visibility of the Kavli IPMU.

Kavli IPMU Director H. Ooguri receiving Medal of Honor attracts wide news coverage

H. Ooguri was named one of the recipients of the Medal of Honor with Purple Ribbon, it was announced on November 3 by the government of Japan. More than 60 media outlets reported the news in Japan, including both national and regional newspapers. More than 30 of these articles cited H. Ooguri as an example of the academic recipients. The news was also reported overseas by the American Mathematical Society, the Aspen Center for Physics, the Institute for Advanced Study, the Simons Foundation, and several others. The Kavli Foundation news section cited H. Ooguri's Medal of Honor with Purple Ribbon in an article introducing the director's research.

Kavli Foundation news section reports on several Kavli IPMU research projects

The Kavli Foundation news section reported on four research projects involving the Kavli IPMU. The first story reported on the Belle II experiment, which involves Kavli IPMU researchers. In particular, it describes the Kavli IPMU's role in developing a part of the Silicon Vertex Detector (SVD), and includes comments from Kavli IPMU Associate Professor T. Higuchi. The second story reported about how when gravity is combined with quantum mechanics, symmetry is not possible. This was a research result uncovered by H. Ooguri and Massachusetts Institute of Technology Assistant Professor D. Harlow. Their paper was published in Physical Review Letters, and was selected as an Editors' Suggestion. The third story reported about how researchers used the world's fastest astrophysical simulation supercomputers ATERUI and ATERUI II to develop an artificial intelligence tool called Dark Emulator. The research team included Principal Investigator M. Takada and Kyoto University Yukawa Institute for Theoretical Physics Project Associate Professor T. Nishimichi (who was also a Kavli IPMU Project Assistant Professor between April 2015 and December 2018, and currently a Kavli IPMU Visiting Scientist). Using the emulator on data recorded by several of the world's largest observational surveys allows researchers to study possibilities concerning the origin of cosmic structures, and how dark matter distribution could have changed over time. The story includes comments from M. Takada. The fourth story introduced the under-development Prime Focus Spectrograph (PFS), an international collaboration led by the Kavli IPMU. The article includes comments from H. Ooguri about how an operational PFS will help researchers study dark energy.

Elegant Mathematics exhibition at UTokyo's Kashiwa Library and the Kavli IPMU

An exhibition exploring the beauty and role of mathematics in everyday life was held at UTokyo's Kashiwa Library from September 13 to October 10, and later at the Kavli IPMU during Open Campus on October 25 and 26. The Elegant Mathematics exhibition was originally developed by Kavli IPMU Professor Y. Itoh during her time at Nagoya University, as part of an activity with the local students to create a mathematics museum. Itoh also gave a public talk during Open Campus regarding her work supervising the exhibition, which was attended by about 110 visitors.

"The Man From the 9 Dimensions" movie supervised by H. Ooguri makes debut in Germany

Visitors to the Hamburg Planetarium in Germany were given the chance to see 3D dome theater movie "The Man From the 9 Dimensions" ("Die Jagd durch die Dimensionen 3D" in German), which was supervised by H. Ooguri, during its three-month run between October and December. The movie explores one of the most pressing questions in modern physics, about the Theory of Everything, and invites the audience to experience the world of superstring theory. Originally developed by Japan's Miraikan as part of the renewal of their permanent exhibition, it was first released in April 2016, and has received several awards, including Best Educational Production Award by the International Planetarium Society in 2016.

Kavli IPMU's "Ask A Scientist" video series continues to attract viewers

Videos explaining the significance of this year's Nobel Prize-winning research, and about Kavli IPMU research areas were added to the institute's ongoing science explained series "はてな宇宙 (Ask A Scientist)". To commemorate Princeton University Emeritus Professor J. Peebles' achievement in receiving the 2019 Nobel Prize in Physics for his theoretical discoveries in cosmology, Kavli IPMU Deputy Director M. Sasaki explained J. Peebles Nobel Prize-winning research in a special episode of Ask A Scientist. M. Sasaki highlighted three points, including the understanding of the presence of helium following the Big Bang, changes in the cosmic microwave background, and the structure of the Universe. The video was first shown during Open Campus (October 25 and 26) at Kashiwa Campus, and later uploaded to the Kavli IPMU's YouTube Channel, where it has been viewed close to 1100 times to date. In December, a video explaining the geometry of quantum mechanics, the 32nd video in the Ask A Scientist series, was uploaded to YouTube. This time the presenter was mathematician A. Macpherson, who was a project researcher at the Kavli IPMU at the time. A. Macpherson's video has since been viewed more than 2250 times to date.

H. Ooguri makes guest appearance on popular TV show "Chiko-chan's Don't Sleep Through Life"

On April 19, H. Ooguri made a guest appearance on public broadcaster NHK General's popular TV show "Chiko-chan's Don't Sleep Through Life". Prior to the airing, a TV film crew had visited the Kavli IPMU to record footage inside the Kavli IPMU building and the Director's office. H. Ooguri appeared on the show as an expert to explain what gravity is to a general audience. "Chiko-chan's

Don't Sleep Through Life" tackles questions that pop up in everyday life through the eyes of its main character, a 5-year-old girl called Chiko-chan. The show features various experts who help explain everyday things to Chiko-chan. A promotional post on Facebook about H. Ooguri's appearance attracted 167 likes on Facebook, and was read by 3444 users.

Kavli IPMU hosts 8th WPI Science Symposium

Hundreds of people attended the 8th WPI Science Symposium on January 12, which was hosted by the Kavli IPMU. More than 480 people gathered at UTokyo's Yasuda Auditorium to take part in this year's symposium "The Power of Mathematics: Bridging Worlds Together", which included a talk by 2015 Nobel Laureate and Kavli IPMU Principal Investigator T. Kajita, who is also the Director of the Institute for Cosmic Ray Research. Other key speakers included H. Ooguri, International Research Center for Neurointelligence Deputy Director K. Aihara, and Advanced Institute for Materials Research former director M. Kotani, who each talked about the impact of mathematics on their own fields, particularly the impact of mathematics on research about the Universe, materials science, and life. This was followed up by a panel discussion between a female researcher, overseas researcher, and young researcher, who with their different backgrounds exchanged stories with the audience about how science became their career. The panelists included Institute for the Advanced Study of Human Biology Professor M. Fujita, International Institute for Integrative Sleep Medicine Principal Investigator M. Lazarus, and Institute for Chemical Reaction Design and Discovery Postdoctoral Fellow K. Kato. Their combined knowledge provided valuable career advice for high school participants. Finally, all 13 WPI institutes were invited to the stage to introduce their institute, and present their institute's research in the exhibition floor directly behind the auditorium, which provided participants with the opportunity to learn about new fields of emerging science.

Organizing workshop for scientist with high-school students and female students

In FY 2019, the Kavli IPMU kept collaborating with CoREF (Consortium for Renovating Education of the Future) to experience the latest advances in scientific research for high-school students. An event was carried out to test the development of an interactive lesson called "From high school physics to frontier research of the Universe", which Kavli IPMU PI H. Murayama and graduate student Y. Katagiri took part in. On August 5, 2019, high school students were invited to try learning about the universe. Another activity to stimulate young female undergraduate and graduate students was carried out under the program "Yes we love Physics-career path for female students majored Physics" on November 30, 2019. The Kavli IPMU has co-hosted this science career event together with the Institute for Solid State Physics and the Institute for Cosmic Ray Research in UTokyo. [(8) of 9 challenges]

7. Center's Response to Results of Last Year's Follow-up

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

* If you have already provided this information, indicate where in the report.

SITE VISIT REPORT

7. Actions required and recommendations

1) *Kavli IPMU might try to let researchers undertake high risk experiments in a new field of their own choosing, and assure them that they should not be afraid to fail. This kind of research freedom in a collaborative atmosphere creates a firestorm of innovation.*

T. Takahashi is applying X-ray imaging techniques he developed for astrophysics research to medical problems such as cancer diagnosis. His in-vivo imaging experiments have started at our lab at the National Cancer Center. A symposium on table-top experiments on dark matter and quantum precision measurements has led to interactions of our high energy theorists with experimenters in quantum optics in Applied Physics Department. We support such visionary and interdisciplinary activities with conferences, visitors, and postdoc hires to make good innovative research atmosphere.

2) *The WG suggests Kavli IPMU to look for possible synergy between survey missions being pursued by Kavli IPMU and collaborations such as LSST and CMB-S4. Such synergy has the*

potential of making Kavli IPMU unique in this area.

We have submitted a LOI to the LSST collaboration and are waiting for its response. For CMB, the LiteBIRD is our top priority. Our long term strategic planning committee recommended us to keep an eye on how the CMB-S4 project will be developed.

3) The WG suggests increasing the number of students and post docs so that IPMU can play a major role in the search for WIMPs as dark matter in XENONnT. This experiment requires Kavli IPMU expertise in Xenon and Gadolinium technologies.

The main charge of our Long Term Strategic Planning Committee was to prioritize uses of our financial and human resources. As our resources are limited, we need to make hard decisions and communicate them clearly to our members. After careful deliberation, the committee identified three priority areas (astronomical surveys, CMB, and Kamioka projects). Though XENONnT was not chosen as our top priority, the committee identified it as an exciting opportunity for the Kavli IPMU, especially with the possibility to make an impact with our Gadolinium technologies. We intend to support the projects with postdocs and students at an appropriate level.

4) The WG wanted to hear an overview presentation of mathematics and theoretical groups with special emphasis on achievements from fusion of various theoretical groups.

We can list some example as follows:

- M. Yamazaki is developing his theory with K. Costello at Perimeter Institute (building on their earlier work with E. Witten) on the connection between four-dimensional gauge theories and two-dimensional integrable models. The connection has led to systematic discoveries of new integrable models.
- S. Kondo (former Kavli IPMU faculty in number theory) and T. Watari (Kavli IPMU string theorist) discovered a remarkable string theoretical interpretation of the L-function of an elliptic curve of Shimura type.
- C.-T. Hsieh (Kavli IPMU-ISSP joint postdoc) is using anomaly and its matching conditions to classify phases of condensed matter systems. He also studied anomaly in the pure Maxwell theory with Y. Tachikawa and K. Yonekura.
- Y. Tachikawa is working on symmetry protected topological phases of matter, building on his expertise on mathematical aspects of quantum field theory.

5) Continued efforts to increase the proportion of female PIs and researchers are needed. The WG is looking forward to Yokoyama's research on the gender issues. The statistical bias is one of the most important part of any analysis. The WG hopes that she can incorporate statistical methods used by physicists into social science research.

At present, our female members are two PIs (7%), two faculty (5%) and 11 Postdocs (20%). The total number of full-employed female researchers is 13 out of 94 (14%), a slight improvement from last year. Weekly Women's Lunch was initiated by Y. Ito, Professor in Mathematics. The group has come up with ideas to improve our environment and research experiences at the Kavli IPMU. We have new diversity requirements for conferences we organize. We are hosting events to encourage female undergraduate/graduate students interested in pursuing careers in physics.

We made a tenure-track faculty offer to a female researcher in Europe, but our offer was declined due to a two-body problem.

We are encouraging H. Yokoyama to work with physicists to incorporate their practices in statistical analysis in her research. She has a background in experimental high energy physics and is well-positioned to do so.

6) The WG would like to see the details of Kavli IPMU diversity policy, especially harassment prevention policy. This should be made public as soon as possible.

We introduced implicit bias training for our hiring and promotion processes. We have established our Code of Conduct which includes harassment prevention policy for all of our members and visitors. The President of UTokyo has directed its Diversity Office of the Central Administration to

spread our diversity initiatives throughout the university, and we are discussing with the Office to implement them.

7) The ability to direct graduate students successfully is an important part of the tenure decision at almost all universities. Currently assistant professors at Kavli-IPMU are not permitted to direct graduate students. Until this issue can be solved, the WG suggests that qualified professor becomes an official supervisor of the student, but the day-to-day supervision is carried out by the assistant professor.

Our new graduate program called WISE approved for the next 7 years by MEXT has enabled all of our tenured faculty interested in supervising graduate students to do so. Our tenure-track faculty members are also getting access to students indirectly through tenured professors.

8) One of the objectives of creating the WPI institutes was to improve the way research is being done in Japan. The reform to globalize UT still has long way to go: breaking of the great wall in the education system between departments and institutes; great wall between departments and the president's office; detailed explanation of employment rules to the foreign researchers; disclosure of the selection procedure in personnel systems, just to mention a few.

We are collaborating with other departments and institutes in many ways. We have established the "Next-generation Neutrino Science Organization" together with ICRR and the UTokyo Faculty of Science, based on the newly defined category for interdisciplinary research. Together with ISSP and the UTokyo Physics Department, we have established "International Institute for Quantum Science," a multi-divisional organization within UTokyo. The LiteBIRD team started to collaborate with the Ohsaki group at the Graduate School of Frontier of Sciences on Kashiwa campus for superconducting technology, and also with the Gonokami-Yumoto-Ideguchi group at Institute for Photon Science and Technology in Hongo campus for laser machining technology.

We have increased transparency in employment through written procedures & rules, for example, hiring a tenure-track faculty member. Other new initiatives include postdoc selection committees, postdoc mentoring, and diversity requirements for our workshops and conferences.

FOLLOW UP REPORT

3. Actions required and recommendations

- *Kavli IPMU needs to develop ways to systematically encourage out-of-the-box thinking, which may lead to breakthroughs.*

Fusion of mathematics, string theory, quantum information and condensed matter physics at the Kavli IPMU have been producing novel interdisciplinary works. We are also encouraging interdisciplinary interactions at the Kavli IPMU by revamping our colloquium series.

- *Planning seems to be one-way from senior to junior researchers. The Director should consider appointing one or two outstanding young researchers to the Long-term Strategic Planning Committee.*

The Long-Term Strategic Planning Committee is not a standing committee. We expect that it is formed only once in 5 to 10 years to discuss our long term plan for the next decade. There are many other ways that we can involve young faculty members in our decision making processes. For example, we have asked KG Lee to chair a committee to discuss computational infrastructure, and he did an excellent job on that.

- *More effort by Kavli IPMU is needed to achieve better diversity, especially in the gender area.*

Mentioned details at 5) of Actions required and recommendations of Site Visit Report above.

Appendix 1 FY 2019 List of Center's Research Results and Main Awards

1. Refereed Papers

- List only the Center's papers published in 2019. (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 "WPI" and the name of the WPI center (WPI-center name)). (Not including papers in which the names of persons affiliated with the WPI program are contained only in acknowledgements.)

B. WPI-related papers

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

Note: On 14 December 2011, the Basic Research Promotion Division in MEXT's Research Promotion Bureau circulated an instruction requiring paper authors to include the name or abbreviation of their WPI center among their institutional affiliations. From 2012, the authors' affiliations must be clearly noted.

(2) Method of listing paper

- List only refereed 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 consistent. (The names of the center researchers do not need to be underlined.)

- If a paper has many authors (say, more than 10), all of their names do not need to be listed.

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

- If the papers are written in languages other than English, underline their serial numbers.

- Order of Listing

A. WPI papers

1. Original articles

2. Review articles

3. Proceedings

4. Other English articles

B. WPI-related papers

1. Original articles

2. Review articles

3. Proceedings

4. Other English articles

(3) Submission of electronic data

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

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

(4) Use in assessments

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

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

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

(5) Additional documents

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

A. WPI papers

1. Original articles

No.	Author names and details
1	Fragileness of exact I-ball/oscillon Ibe, M; Kawasaki, M; Nakano, W; Sonomoto, E PHYSICAL REVIEW D 100(12), 125021, DEC 31, 2019
2	Gluing gravitational blocks for AdS black holes Hosseini, SM; Hristov, K; Zaffaroni, A JOURNAL OF HIGH ENERGY PHYSICS (12), 168, DEC 30, 2019
3	Reflection groups and 3d $N \geq 6$ SCFTs Tachikawa, Y; Zafrir, G JOURNAL OF HIGH ENERGY PHYSICS (12), 176, DEC 30, 2019

4	Bino-wino coannihilation as a prediction in the E-7 unification of families Yanagida, TT; Yin, W; Yokozaki, N JOURNAL OF HIGH ENERGY PHYSICS (12), 169, DEC 30, 2019
5	Measurement of neutrino and antineutrino neutral-current quasielasticlike interactions on oxygen by detecting nuclear deexcitation gamma rays Abe, K et al. PHYSICAL REVIEW D 100(11), 112009, DEC 30, 2019
6	Clustering of primordial black holes formed in a matter-dominated epoch Matsubara, T; Terada, T; Kohri, K; Yokoyama, S PHYSICAL REVIEW D 100(12), 123544, DEC 30, 2019
7	First Identification of 10 kpc [C II] 158 μ m Halos around Star-forming Galaxies at $z=5-7$ Fujimoto, S; Ouchi, M; Ferrara, A; Pallottini, A; Ivison, RJ; Behrens, C; Gallerani, S; Arata, S; Yajima, H; Nagamine, K ASTROPHYSICAL JOURNAL 887(2), 107, DEC 20, 2019
8	On the absence of conformally flat slicings of the Kerr spacetime De Felice, A; Larrouturou, F; Mukohyama, S; Olmos, M PHYSICAL REVIEW D 100(12), 124044, DEC 17, 2019
9	Smallest halos in thermal wino dark matter Ando, S; Kamada, A; Sekiguchi, T; Takahashi, T PHYSICAL REVIEW D 100(12), 123519, DEC 16, 2019
10	Leptogenesis from spontaneous symmetry breaking during inflation Wu, YP; Yang, L; Kusenko, A JOURNAL OF HIGH ENERGY PHYSICS (12), 88, DEC 11, 2019
11	Search for Astronomical Neutrinos from Blazar TXS 0506+056 in Super-Kamiokande Hagiwara, K et al. ASTROPHYSICAL JOURNAL LETTERS 887(1), L6, DEC 10, 2019
12	Where Do Quasar Hosts Lie with Respect to the Size-Mass Relation of Galaxies? Silverman, JD; Treu, T; Ding, XH; Jahnke, K; Bennert, VN; Birrer, S; Schramm, M; Schulze, A; Kartaltepe, JS; Sanders, DB; Cen, RY ASTROPHYSICAL JOURNAL LETTERS 887(1), L5, DEC 10, 2019
13	TARDIS. I. A Constrained Reconstruction Approach to Modeling the z similar to 2.5 Cosmic Web Probed by Ly alpha Forest Tomography Horowitz, B; Lee, KG; White, M; Krolewski, A; Ata, M ASTROPHYSICAL JOURNAL 887(1), 61, DEC 10, 2019
14	Pulsational Pair-instability Supernovae. I. Pre-collapse Evolution and Pulsational Mass Ejection Leung, SC; Nomoto, K; Blinnikov, S ASTROPHYSICAL JOURNAL 887(1), 72, DEC 10, 2019
15	The Nature of Ionized Gas in the Milky Way Galactic Fountain Werk, JK; Rubin, KHR; Bish, HV; Prochaska, JX; Zheng, Y; O'Meara, JM; Lenz, D; Hummels, C; Deason, AJ ASTROPHYSICAL JOURNAL 887(1), 89, DEC 10, 2019
16	Quintessence axion revisited in light of swampland conjectures Ibe, M; Yamazaki, M; Yanagida, TT CLASSICAL AND QUANTUM GRAVITY 36(23), 235020, DEC 5, 2019
17	The Belle II Physics Book Kou, E et al. PROGRESS OF THEORETICAL AND EXPERIMENTAL PHYSICS (12), 123C01, DEC, 2019

18	Conic divisorial ideals of Hibi rings and their applications to non-commutative crepant resolutions Higashitani, A; Nakajima, Y SELECTA MATHEMATICA-NEW SERIES 25(5), UNSP 78, DEC, 2019
19	The circle quantum group and the infinite root stack of a curve Sala, F; Schiffmann, O SELECTA MATHEMATICA-NEW SERIES 25(5), UNSP 77, DEC, 2019
20	Second data release of the Hyper Suprime-Cam Subaru Strategic Program Aihara, H et al. PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 71(6), 114, DEC, 2019
21	Subaru High-z Exploration of Low-Luminosity Quasars (SHELLOs). VIII. A less biased view of the early co-evolution of black holes and host galaxies Izumi, T et al. PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 71(6), 111, DEC, 2019
22	MeV-scale reheating temperature and thermalization of oscillating neutrinos by radiative and hadronic decays of massive particles Hasegawa, T; Hiroshima, N; Kohri, K; Hansen, RSL; Tram, T; Hannestad, S JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (12), 12, DEC, 2019
23	The thermal-radiative wind in low-mass X-ray binary H1743-322: radiation hydrodynamic simulations Tomaru, R; Done, C; Ohsuga, K; Nomura, M; Takahashi, T MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(3), pp.3098-3111, DEC, 2019
24	Secondary CMB temperature anisotropies from magnetic reheating Saga, S; Ota, A; Tashiro, H; Yokoyama, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(3), pp.4419-4427, DEC, 2019
25	On the measurements of assembly bias and splashback radius using optically selected galaxy clusters Sunayama, T; More, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(4), pp.4945-4955, DEC, 2019
26	Galaxy-Galaxy lensing in HSC: Validation tests and the impact of heterogeneous spectroscopic training sets Speagle, JS; Leauthaud, A; Huang, S; Bradshaw, CP; Ardila, F; Capak, PL; Eisenstein, DJ; Masters, DC; Mandelbaum, R; More, S; Simet, M; Sifon, C MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(4), pp.5658-5677, DEC, 2019
27	Evolution of the Cool Gas in the Circumgalactic Medium of Massive Halos: A Keck Cosmic Web Imager Survey of Ly alpha Emission around QSOs at z approximate to 2 Cai, Z; Cantalupo, S; Prochaska, JX; Battaia, FA; Burchett, J; Li, Q; Chisholm, J; Bundy, K; Hennawi, JF ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES 245(2), 23, DEC, 2019
28	Molecular clouds in the Cosmic Snake normal star-forming galaxy 8 billion years ago Dessauges-Zavadsky, M; Richard, J; Combes, F; Schaerer, D; Rujopakarn, W; Mayer, L; Cava, A; Boone, F; Egami, E; Kneib, JP; Perez-Gonzalez, PG; Pfenniger, D; Rawle, TD; Teysier, R; van der Werf, PP NATURE ASTRONOMY 3(12), pp.1115-1121, DEC, 2019

29	New Constraint on the Atmosphere of (50000) Quaoar from a Stellar Occultation Arimatsu, K et al. ASTRONOMICAL JOURNAL 158(6), 236, DEC, 2019
31	A SHARP view of HOLiCOW: H-0 from three time-delay gravitational lens systems with adaptive optics imaging Chen, GCF et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(2), pp.1743-1773, DEC, 2019
32	Studying high-z galaxies with [C II] intensity mapping Yue, B; Ferrara, A MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(2), pp.1928-1943, DEC, 2019
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34	Entanglement Wedges from the Information Metric in Conformal Field Theories Suzuki, Y; Takayanagi, T; Umemoto, K PHYSICAL REVIEW LETTERS 123(22), 221601, NOV 26, 2019
35	On gapped boundaries for SPT phases beyond group cohomology Kobayashi, R; Ohmori, K; Tachikawa, Y JOURNAL OF HIGH ENERGY PHYSICS (11), 131, NOV 22, 2019
36	Does boundary distinguish complexities? Sato, Y; Watanabe, K JOURNAL OF HIGH ENERGY PHYSICS (11), 132, NOV 22, 2019
37	Wall-crossing and operator ordering for 't Hooft operators in N=2 gauge theories Hayashi, H; Okuda, T; Yoshida, Y JOURNAL OF HIGH ENERGY PHYSICS (11), 116, NOV 21, 2019
38	A very-high-energy component deep in the gamma-ray burst afterglow Abdalla, H et al. NATURE 575(7783), pp.464-467, NOV 21, 2019
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43	Evolution of ONeMg Core in Super-AGB Stars toward Electron-capture Supernovae: Effects of Updated Electron-capture Rate Zha, S; Leung, SC; Suzuki, T; Nomoto, K ASTROPHYSICAL JOURNAL 886(1), 22, NOV 20, 2019
44	Microstates of rotating AdS5 strings Hosseini, SM; Hristov, K; Zaffaroni, A JOURNAL OF HIGH ENERGY PHYSICS (11), 90, NOV 15, 2019
45	Strongly lensed SNe Ia in the era of LSST: observing cadence for lens discoveries and time-delay measurements Huber, S; Suyu, SH; Noebauer, UM; Bonvin, V; Rothchild, D; Chan, JHH; Awan, H; Courbin, F; Kromer, M; Marshall, P; Oguri, M; Ribeiro, T ASTRONOMY & ASTROPHYSICS 631, A161, NOV 15, 2019
46	Formation of supermassive primordial black holes by Affleck-Dine mechanism Kawasaki, M; Murai, K PHYSICAL REVIEW D 100(10), 103521, NOV 15, 2019
47	Direct limits on the interaction of antiprotons with axion-like dark matter Smorra, C et al. NATURE 575(7782), pp.310-314, NOV 14, 2019
48	Amplitudes, resonances, and the ultraviolet completion of gravity Alonso, R; Urbano, A PHYSICAL REVIEW D 100(9), 95013, NOV 14, 2019
49	Hidden treasures: Sterile neutrinos as dark matter with miraculous abundance, structure formation for different production mechanisms, and a solution to the $\sigma(8)$ problem Abazajian, KN; Kusenko, A PHYSICAL REVIEW D 100(10), 103513, NOV 12, 2019
50	Positive geometry in the diagonal limit of the conformal bootstrap Sen, K; Sinha, A; Zahed, A JOURNAL OF HIGH ENERGY PHYSICS (11), 59, NOV 11, 2019
51	Super-sample tidal modes on the celestial sphere Akitsu, K; Sugiyama, NS; Shiraishi, M PHYSICAL REVIEW D 100(10), 103515, NOV 11, 2019
52	Sensitivity of Super-Kamiokande with Gadolinium to Low Energy Antineutrinos from Pre-supernova Emission Simpson, C et al. ASTROPHYSICAL JOURNAL 885(2), 133, NOV 10, 2019
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56	More about Q-ball with elliptical orbit Hasegawa, F; Hong, JP; Suzuki, M PHYSICS LETTERS B 798, 135001, NOV 10, 2019
57	Dark matter and baryon-number generation in quintessential inflation via hierarchical right-handed neutrinos Hashiba, S; Yokoyama, J PHYSICS LETTERS B 798, 135024, NOV 10, 2019
58	A direct measurement of the O-17(alpha, gamma)Ne-21 reaction in inverse kinematics and its impact on heavy element production Taggart, MP et al. PHYSICS LETTERS B 798, 134894, NOV 10, 2019
59	Intrinsic alignment statistics of density and velocity fields at large scales: Formulation, modeling, and baryon acoustic oscillation features Okumura, T; Taruya, A; Nishimichi, T PHYSICAL REVIEW D 100(10), 103507, NOV 7, 2019
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63	Detecting the neutral IGM in filaments with the SKA Kooistra, R; Silva, MB; Zaroubi, S; Verheijen, MAW; Tempel, E; Hess, KM MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 490(1), pp.1415-1424, NOV, 2019
64	A Rapidly Declining Transient Discovered with the Subaru/Hyper Suprime-Cam Tominaga, N; Morokuma, T; Tanaka, M; Yasuda, N; Furusawa, H; Tanaka, M; Jiang, JA; Tolstov, A; Blinnikov, S; Doi, M; Iwata, I; Kuncarayakti, H; Moriya, TJ; Nagao, T; Nomoto, K; Noumaru, J; Takata, T ASTROPHYSICAL JOURNAL 885(1), 13, NOV 1, 2019
65	Radiative transfer distortions of Lyman alpha emitters: a new Fingers-of-God damping in the clustering in redshift space Byrohl, C; Saito, S; Behrens, C MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 489(3), pp.3472-3491, NOV, 2019
66	The contribution from rotating massive stars to the enrichment in Sr and Ba of the Milky Way Rizzuti, F; Cescutti, G; Matteucci, F; Chieffi, A; Hirschi, R; Limongi, M MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 489(4), pp.5244-5255, NOV, 2019
67	Anomaly Matching and Symmetry-Protected Critical Phases in SU(N) Spin Systems in 1+1 Dimensions Yao, Y; Hsieh, CT; Oshikawa, M PHYSICAL REVIEW LETTERS 123(18), 180201, OCT 31, 2019
68	On the Regge limit of Fishnet correlators Chowdhury, SD; Haldar, P; Sen, K JOURNAL OF HIGH ENERGY PHYSICS (10), 249, OCT 25, 2019

69	Inferring the velocity of early massive stars from the abundances of extremely metal-poor stars Choplin, A; Tominaga, N; Ishigaki, MN ASTRONOMY & ASTROPHYSICS 632, A62, OCT 22, 2019
70	SDSS-IV MaNGA: Evidence for Enriched Accretion onto Satellite Galaxies in Dense Environments Schaefer, AL; Tremonti, C; Pace, Z; Belfiore, F; Argudo-Fernandez, M; Bershadsky, MA; Drory, N; Jones, A; Maiolino, R; Stark, D; Wake, D; Yan, RB ASTROPHYSICAL JOURNAL 884(2), 156, OCT 20, 2019
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72	Correlated magnetic noise from anisotropic lightning sources and the detection of stochastic gravitational waves Himemoto, Y; Taruya, A PHYSICAL REVIEW D 100(8), 82001, OCT 17, 2019
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421	Generalized dilaton-axion models of inflation, de Sitter vacua and spontaneous SUSY breaking in supergravity Aldabergenov, Y; Chatrabhuti, A; Ketov, SV EUROPEAN PHYSICAL JOURNAL C 79(8), 713, AUG, 2019

422	The COS Absorption Survey of Baryon Harbors: The Galaxy Database and Cross-correlation Analysis of O VI Systems Prochaska, JX; Burchett, JN; Tripp, TM; Werk, JK; Willmer, CNA; Howk, JC; Lange, S; Tejos, N; Meiring, JD; Tumlinson, J; Lehner, N; Ford, AB; Dave, R ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES 243(2), 24, AUG, 2019
423	The Event Horizon General Relativistic Magnetohydrodynamic Code Comparison Project Porth, O et al. ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES 243(2), 26, AUG, 2019
424	Photoevaporation of Jeans-unstable molecular clumps Decataldo, D; Pallottini, A; Ferrara, A; Vallini, L; Gallerani, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 487(3), pp.3377-3391, AUG, 2019
425	CMB constraints on the stochastic gravitational-wave background at Mpc scales Namikawa, T; Saga, S; Yamauchi, D; Taruya, A PHYSICAL REVIEW D 100(2), 21303, JUL 19, 2019
426	Learning to predict the cosmological structure formation He, SY; Li, Y; Feng, Y; Ho, S; Ravanbakhsh, S; Chen, W; Poczós, B PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 116(28), pp.13825-13832, JUL 9, 2019
427	HESS and Suzaku observations of the Vela X pulsar wind nebula Abdalla, H et al. ASTRONOMY & ASTROPHYSICS 627, A100, JUL 8, 2019
428	HESS observations of the flaring gravitationally lensed galaxy PKS 1830-211 Abdalla, H et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 486(3), pp.3886-3891, JUL, 2019
429	Evidence for the accretion origin of halo stars with an extreme r-process enhancement Xing, QF; Zhao, G; Aoki, W; Honda, S; Li, HN; Ishigaki, MN; Matsuno, T NATURE ASTRONOMY 3(7), pp.631-635, JUL, 2019
430	Gamma-ray glow preceding downward terrestrial gamma-ray flash Wada, Y; Enoto, T; Nakamura, Y; Furuta, Y; Yuasa, T; Nakazawa, K; Morimoto, T; Sato, M; Matsumoto, T; Yonetoku, D; Sawano, T; Sakai, H; Kamogawa, M; Ushio, T; Makishima, K; Tsuchiya, H COMMUNICATIONS PHYSICS 2, 67, JUN 25, 2019
431	Nonparametric Dark Energy Reconstruction Using the Tomographic Alcock-Paczynski Test Zhang, ZY; Gu, G; Wang, XM; Li, YH; Sabiu, CG; Park, H; Miao, HT; Luo, XL; Fang, F; Li, XD ASTROPHYSICAL JOURNAL 878(2), 137, JUN 20, 2019
432	Trimaximal neutrino mixing from modular A(4) invariance with residual symmetries Novichkov, PP; Petcov, ST; Tanimoto, M PHYSICS LETTERS B 793, pp.247-258, JUN 10, 2019
434	Ly alpha emission from galaxies in the Epoch of eionization Behrens, C; Pallottini, A; Ferrara, A; Gallerani, S; Vallini, L MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 486(2), pp.2197-2209, JUN, 2019
435	Exploring physical features of anisotropic strange stars beyond standard maximum mass limit in f (R, T) gravity Deb, D; Ketov, SV; Maurya, SK; Khlopov, M; Moraes, PHRS; Ray, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 485(4), pp.5652-5665, JUN, 2019

436	Broadband Intensity Tomography: Spectral Tagging of the Cosmic UV Background Chiang, YK; Menard, B; Schiminovich, D ASTROPHYSICAL JOURNAL 877(2), 150, JUN 1, 2019
437	Subpixel response of SOI pixel sensor for X-ray astronomy with pinned depleted diode: first result from mesh experiment Kayama, K et al. JOURNAL OF INSTRUMENTATION 14, C06005, JUN, 2019
438	The Complete Calibration of the Color-Redshift Relation (C3R2) Survey: Analysis and Data Release 2 Masters, DC; Stern, DK; Cohen, JG; Capak, PL; Stanford, SA; Hernitschek, N; Galametz, A; Davidzon, I; Rhodes, JD; Sanders, D; Mobasher, B; Castander, F; Pruet, K; Fotopoulou, S ASTROPHYSICAL JOURNAL 877(2), 81, JUN 1, 2019
439	Direct Measurement of the Cosmic-Ray Proton Spectrum from 50 GeV to 10 TeV with the Calorimetric Electron Telescope on the International Space Station Adriani, O et al. PHYSICAL REVIEW LETTERS 122(18), 181102, MAY 10, 2019
440	Evidence for an Aspherical Population III Supernova Explosion Inferred from the Hyper-metal-poor Star HE 1327-2326 Ezzeddine, R; Frebel, A; Roederer, IU; Tominaga, N; Tumlinson, J; Ishigaki, M; Nomoto, K; Placco, VM; Aoki, W ASTROPHYSICAL JOURNAL 876(2), 97, MAY 10, 2019
441	Vibration isolation system with a compact damping system for power recycling mirrors of KAGRA Akiyama, Y et al. CLASSICAL AND QUANTUM GRAVITY 36(9), 95015, MAY 9, 2019
442	Investigating the properties of stripped-envelope supernovae; what are the implications for their progenitors? Prentice, SJ et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 485(2), pp.1559-1578, MAY, 2019
443	Analytical Model of Time-Dependent Ionization in the Envelopes of Type II Supernovae at the Photospheric Phase Potashov, MS; Blinnikov, SI ASTRONOMY LETTERS-A JOURNAL OF ASTRONOMY AND SPACE ASTROPHYSICS 45(5), pp.276-281, MAY, 2019
444	Cell cycle- and genomic distance-dependent dynamics of a discrete chromosomal region Ma, HH; Tu, LC; Chung, YC; Naseri, A; Grunwald, D; Zhang, SJ; Pederson, T JOURNAL OF CELL BIOLOGY 218(5), pp.1467-1477, MAY, 2019
445	Extreme Debris Disk Variability: Exploring the Diverse Outcomes of Large Asteroid Impacts During the Era of Terrestrial Planet Formation Su, KYL; Jackson, AP; Gaspar, A; Rieke, GH; Dong, RB; Olofsson, J; Kennedy, GM; Leinhardt, ZM; Malhotra, R; Hammer, M; Meng, HYA; Rujopakarn, W; Rodriguez, JE; Pepper, J; Reichart, DE; James, D; Stassun, KG ASTRONOMICAL JOURNAL 157(5), 202, MAY, 2019

446	The shapes of the rotation curves of star-forming galaxies over the last approximate to 10 Gyr Tiley, AL; Swinbank, AM; Harrison, CM; Smail, I; Turner, OJ; Schaller, M; Stott, JP; Sobral, D; Theuns, T; Sharples, RM; Gillman, S; Bower, RG; Bunker, AJ; Best, P; Richard, J; Bacon, R; Bureau, M; Cirasuolo, M; Magdis, G MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 485(1), pp.934-960, MAY, 2019
447	Large-area MPPC with enhanced VUV sensitivity for liquid xenon scintillation detector Ieki, K; Iwamoto, T; Kaneko, D; Kobayashi, S; Matsuzawa, N; Mori, T; Ogawa, S; Onda, R; Ootani, W; Sawada, R; Sato, K; Yamada, R NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT 925, pp.148-155, MAY 1, 2019
448	Higher Kac-Moody algebras and moduli spaces of G-bundles Faonte, G; Hennion, B; Kapranov, M ADVANCES IN MATHEMATICS 346, pp.389-466, APR 13, 2019
449	Polonyi-Starobinsky supergravity with inflaton in a massive vector multiplet with DBI and FI terms Abe, H; Aldabergenov, Y; Aoki, S; Ketov, SV CLASSICAL AND QUANTUM GRAVITY 36(7), 75012, APR 11, 2019
450	Testing Shear Recovery with Field Distortion Zhang, J; Dong, FY; Li, HK; Li, XC; Li, YK; Liu, DZ; Luo, WT; Fu, LP; Li, GL; Fan, ZH ASTROPHYSICAL JOURNAL 875(1), 48, APR 10, 2019
451	First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L1, APR 10, 2019
452	First M87 Event Horizon Telescope Results. V. Physical Origin of the Asymmetric Ring Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L5, APR 10, 2019
453	First M87 Event Horizon Telescope Results. III. Data Processing and Calibration Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L3, APR 10, 2019
454	First M87 Event Horizon Telescope Results. II. Array and Instrumentation Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L2, APR 10, 2019
455	First M87 Event Horizon Telescope Results. IV. Imaging the Central Supermassive Black Hole Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L4, APR 10, 2019
456	First M87 Event Horizon Telescope Results. VI. The Shadow and Mass of the Central Black Hole Akiyama, K et al. ASTROPHYSICAL JOURNAL LETTERS 875(1), L6, APR 10, 2019
457	An enigmatic hump around 30 keV in Suzaku spectra of Aquila X-1 in the hard state Kubota, M; Tamagawa, T; Makishima, K; Nakano, T; Iwakiri, W; Sugizaki, M; Ono, K PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 71(2), 33, APR, 2019
458	String-Theory Realization of Modular Forms for Elliptic Curves with Complex Multiplication Kondo, S; Watari, T COMMUNICATIONS IN MATHEMATICAL PHYSICS 367(1), pp.89-126, APR, 2019

459	Supernova dust yields: the role of metallicity, rotation, and fallback Marassi, S; Schneider, R; Limongi, M; Chieffi, A; Graziani, L; Bianchi, S MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 484(2), pp.2587-2604, APR, 2019
460	CGM properties in VELA and NIHAO simulations; the OVI ionization mechanism: dependence on redshift, halo mass, and radius Roca-Fabrega, S; Dekel, A; Faerman, Y; Gnat, O; Strawn, C; Ceverino, D; Primack, J; Maccio, AV; Dutton, AA; Prochaska, JX; Stern, J MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 484(3), pp.3625-3645, APR, 2019
461	Nature of blackbody stars Serenelli, A; Rohrmann, RD; Fukugita, M ASTRONOMY & ASTROPHYSICS 623, A177, MAR 28, 2019
462	Perturbation theory challenge for cosmological parameters estimation: Matter power spectrum in real space Osato, K; Nishimichi, T; Bernardeau, F; Taruya, A PHYSICAL REVIEW D 99(6), 63530, MAR 25, 2019
463	Energetics of high-energy cosmic radiations Murase, K; Fukugita, M PHYSICAL REVIEW D 99(6), 63012, MAR 18, 2019
464	METAPLECTIC COVERS OF KAC-MOODY GROUPS AND WHITTAKER FUNCTIONS Patnaik, MM; Puskas, A DUKE MATHEMATICAL JOURNAL 168(4), pp.553-653, MAR 15, 2019
465	CMB lensing bispectrum: Assessing analytical predictions against full-sky lensing simulations Namikawa, T; Bose, B; Bouchet, FR; Takahashi, R; Taruya, A PHYSICAL REVIEW D 99(6), 63511, MAR 12, 2019
466	Stochastic modeling of 3-D compositional distribution in the crust with Bayesian inference and application to geoneutrino observation in Japan Takeuchi, N; Ueki, K; Iizuka, T; Nagao, J; Tanaka, A; Enomoto, S; Shirahata, Y; Watanabe, H; Yamano, M; Tanaka, HKM PHYSICS OF THE EARTH AND PLANETARY INTERIORS 288, pp.37-57, MAR, 2019
467	Revisiting electroweak phase transition in the standard model with a real singlet scalar Chiang, CW; Li, YT; Senaha, E PHYSICS LETTERS B 789, pp.154-159, FEB 10, 2019
468	The interstellar medium of dwarf galaxies: new insights from Machine Learning analysis of emission-line spectra Ucci, G; Ferrara, A; Gallerani, S; Pallottini, A; Cresci, G; Kehrig, C; Hunt, LK; Vilchez, JM; Vanzì, L MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 483(1), pp.1295-1313, FEB, 2019
469	Substructures associated with the sloshing cold front in the Perseus cluster Ichinohe, Y; Simionescu, A; Werner, N; Fabian, AC; Takahashi, T MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 483(2), pp.1744-1753, FEB, 2019
470	Moduli of Bridgeland semistable objects on 3-folds and Donaldson-Thomas invariants Piyaratne, D; Toda, Y JOURNAL FÜR DIE REINE UND ANGEWANDTE MATHEMATIK 747, pp.175-219, FEB, 2019

471	Angular power spectrum analysis on current and future high-energy neutrino data Dekker, A; Ando, S JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS (2), 2, FEB, 2019
472	The Fifteenth Data Release of the Sloan Digital Sky Surveys: First Release of MaNGA-derived Quantities, Data Visualization Tools, and Stellar Library Aguado, DS et al. ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES 240(2), 23, FEB, 2019
473	Particle transport within the pulsar wind nebula HESS J1825-137 Abdalla, H et al. ASTRONOMY & ASTROPHYSICS 621, A116, JAN 15, 2019
474	[C II] 158 μ m Emission from z similar to 4 H I Absorption-selected Galaxies Neeleman, M; Kanekar, N; Prochaska, JX; Rafelski, MA; Carilli, CL ASTROPHYSICAL JOURNAL LETTERS 870(2), L19, JAN 10, 2019
475	Extragalactic Imprints in Galactic Dust Maps Chiang, YK; Menard, B ASTROPHYSICAL JOURNAL 870(2), 120, JAN 10, 2019
476	The 2014TeV gamma-Ray Flare of Mrk 501 Seen with HESS: Temporal and Spectral Constraints on Lorentz Invariance Violation Abdalla, H et al. ASTROPHYSICAL JOURNAL 870(2), 93, JAN 10, 2019
477	Counting conics on sextic 4-folds Cao, YL MATHEMATICAL RESEARCH LETTERS 26(5), pp.1343-1357, 2019
478	Preliminaries Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.1-8, 2019
479	Topological 1-Segal and 2-Segal Spaces Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.9-30, 2019
480	Discrete 2-Segal Spaces Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.31-70, 2019
481	Model Categories and Bousfield Localization Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.71-84, 2019
482	The 1-Segal and 2-Segal Model Structures Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.85-94, 2019
483	The Path Space Criterion for 2-Segal Spaces Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.95-106, 2019
484	2-Segal Spaces from Higher Categories Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.107-124, 2019
485	Hall Algebras Associated to 2-Segal Spaces Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.125-151, 2019

486	Hall (infinity, 2)-Categories Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.153-167, 2019
487	An (infinity, 2)-Categorical Theory of Spans Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.169-199, 2019
488	2-Segal Spaces as Monads in Bispans Dyckerhoff, T; Kapranov, M HIGHER SEGAL SPACES 2244, pp.201-208, 2019
490	Inflation, dark energy, and dark matter in supergravity Ketov, SV; Aldabergenov, Y ASTRONOMISCHE NACHRICHTEN 340(1-3), pp.126-130, JAN-MAR, 2019
491	A NuSTAR study of the 55 ks hard X-ray pulse-phase modulation in the magnetar 4U 0142+61 Makishima, K; Murakami, H; Enoto, T; Nakazawa, K PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 71(1), 15, JAN, 2019
492	Modified Born-Infeld-Dilaton-Axion Coupling in Supersymmetry Aldabergenov, Y; Ketov, SV SYMMETRY-BASEL 11(1), 14, JAN, 2019
494	KROSS-SAMI: a direct IFS comparison of the Tully-Fisher relation across 8 Gyr since z approximate to 1 Tiley, AL et al. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 482(2), pp.2166-2188, JAN, 2019
495	On the nature and physical conditions of the luminous Ly alpha emitter CR7 and its rest-frame UV components Sobral, D; Matthee, J; Brammer, G; Ferrara, A; Alegre, L; Rottgering, H; Schaerer, D; Mobasher, B; Darvish, B MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 482(2), pp.2422-2441, JAN, 2019
496	Image simulations for gravitational lensing with SKYLENS Plazas, AA; Meneghetti, M; Maturi, M; Rhodes, J MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 482(2), pp.2823-2832, JAN, 2019

2. Review articles

395	Modified Gravity in Higher Dimensions, Flux Compactification, and Cosmological Inflation Ketov, SV SYMMETRY-BASEL 11(12), 1528, DEC, 2019
433	FCC Physics Opportunities: Future Circular Collider Conceptual Design Report Volume 1 Abada, A et al. EUROPEAN PHYSICAL JOURNAL C 79(6), 474, JUN 5, 2019
489	Cosmological acceleration Blinnikov, SI; Dolgov, AD PHYSICS-USPEKHI 62(6), pp.529-567, 2019
493	KAGRA: 2.5 generation interferometric gravitational wave detector Akutsu, T et al. NATURE ASTRONOMY 3(1), pp.35-40, JAN, 2019

3. Proceedings

4. Other English articles

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

- List up to 10 main presentations during FY 2019 in order from most recent.
- For each, write the date(s), lecturer/presenter's name, presentation title, and conference name.

Date(s)	Lecturer/Presenter's name	Presentation title	Conference name
2019/12/18	Mark Vagins	Supernova Neutrinos in a Gd-loaded SK	Prospects in Neutrino Physics (NuPhys 2019)
2019/11/17	Naoyuki Tamura	PFS: The next generation Subaru's facility instrument under integration	Subaru Telescope 20th anniversary conference
2019/10/12	Misao Sasaki	Perspectives on Gravitational Wave Cosmology	International Meeting on Gravitational Wave Physics
2019/9/9	Hitoshi Murayama	Dark matter candidates and strategies for future	The 16th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2019)
2019/9/4	Shigeki Matsumoto	Light Fermionic Thermal Dark Matter with Light Scalar Mediator	Particle Astrophysics and Cosmology Including Fundamental Interactions 2019 (PACIFIC 2019)
2019/8/5	Yukinobu Toda	On categorical Donaldson-Thomas theory for local surfaces	The Conference on algebraic and arithmetic geometry
2019/8/2	Hiraku Nakajima	Bow varieties - I, II	Focus week on quiver varieties
2019/7/1	Masahiro Takada	Challenges in large-scale structure cosmology	Dynamics of Large-scale Structure Formation
2019/6/14	Mikhail Kapranov	Perverse sheaves and the algebra of the infrared	Resurgence in Mathematics and Physics
2019/5/20	Hiroshi Ooguri	Swampland and Its Physical Implications	The 27th International Conference on Supersymmetry and Unification of Fundamental Interactions (SUSY 2019)

3. Major Awards

- List up to 10 main awards received during FY 2019 in order from the most recent.
- For each, write the date issued, the recipient's name, and the name of award.
- In case of multiple recipients, underline those affiliated with the center.

Date	Recipient's name	Name of award
2020/3/16	Keigo Nakamura	Young Scientist Award of the Physical Society of Japan, 2020
2020/1/27	Shiro Ikeda (The Event Horizon Telescope Collaboration)	Einstein Medal 2020
2019/12/21	Kei Kano, Eri Mizumachi, <u>Yuko Ikkatai</u>	Japan Society for Science Education Best Presentation Award for Young scientist 2019
2019/11/3	Hiroshi Ooguri	Medal of Honor with Purple Ribbon
2019/9/18	Keigo Nakamura	High Energy Physics Young Researcher's Award 2019
2019/9/1	Masaki Oshikawa	American Physical Society Fellow 2019
2019/8/27	Young-Kee Kim	2019 Scientist of the Year jointly by the Korean Scientists and Engineers Association (US) and the Korean Federation of Science and Technology Societies (Korea)
2019/7/26	Takaaki Kajita	IUPAP-TIFR Homi Bhabha Medal and Prize
2019/4/13	Ken'ichi Nomoto	2019 Hans A. Bethe Prize
2019/3/11	Takeshi Saito <u>Yasuyuki Kawahigashi</u> <u>Toshiyuki Kobayashi</u>	The Mathematical Society of Japan Publication Prize (2019)

Appendix 2 FY 2019 List of Principal Investigators

NOTE:

*Underline names of principal investigators who belong to an overseas research institution.

*In the case of researcher(s) not listed in the latest report or, for centers selected in FY2012 in the progress report for Extension application screening, attach a "Biographical Sketch of a New Principal Investigator"(Appendix 2)

<Results at the end of FY2019>							Principal Investigators Total: 28
Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
<u>Center director</u> <u>Hiroshi Ooguri</u>	58	Director Kavli IPMU, UTIAS, The Univ. of Tokyo Director and Fred Kavli Professor Walter Burke Institute for Theoretical Physics California Institute of Technology	Ph.D. Theoretical Physics (Mathematical Physics)	50	10/1/2007	Stays at Kavli IPMU 6 months a year. Joins videoconference once a week for the rest of 6 months.	Organized an International workshop mainly for young researchers. Invited 2 professor (43 days & 15 days) to do research discussion and 1 PhD Student (5 days) as a seminar speaker.
Hiroaki Aihara	64	Deputy Director Kavli IPMU, UTIAS, The Univ. of Tokyo Executive Director and Vice President The Univ. of Tokyo	Ph.D. Experimental Physics (High Energy Physics)	30	10/1/2007	Stays at Kavli IPMU once a month. Joins videoconference once a week.	
<u>Alexey Bondal</u>	58	Professor Steklov Mathematical Institute Project Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Mathematics	40	10/1/2007	Stays at Kavli IPMU 6 months a year. Joins videoconference once a week for the rest of 6 months.	Invited 1 professor (7 days) to do research discussion and 2 young professors (6 days & 3 days) to hold seminars.
Kentaro Hori	54	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Theoretical Physics (String Theory)	80	11/1/2008	Stays at Kavli IPMU full time.	
Kunio Inoue	54	Professor, Director Research Center for Neutrino Science, Tohoku University	Ph.D. Experimental Physics (Neutrino Physics)	45	10/1/2007	Stays at Kamioka Branch once a week.	

Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
Takaaki Kajita	61	Director, Professor ICRR, The Univ. of Tokyo	Ph.D. Experimental Physics (Neutrino Physics)	10	10/1/2007	Stays at Kamioka Branch once a month. Usually stays at ICRR which is right next to Kavli IPMU.	
Mikhail Kapranov	57	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Mathematics	100	5/16/2014	Stays at Kavli IPMU full time.	
<u>Stavros Katsanevas</u>	66	Professor, Université Paris Denis Diderot Director laboratory of Astroparticle Physics and Cosmology (APC) Director European Gravitational Observatory	Ph.D. Astroparticle Physics	10	10/1/2007	Joins videoconference once a month.	Encouraging researches on experimental physics and female researchers.
Masahiro Kawasaki	59	Professor ICRR, The Univ. of Tokyo	Ph.D. Theoretical Physics (Cosmology)	40	8/1/2015	Stays at Kavli IPMU twice a week.	
<u>Young-Kee Kim</u>	57	Louis Block Distinguished Service Professor Dept. of Physics, University of Chicago	Ph.D. Physics	10	4/1/2017	Stays at Kavli IPMU once a year. Joins videoconference once a month.	Encouraging researches on neutrino physics and astroparticle physics.
Toshiyuki Kobayashi	57	Professor Graduate School of Mathematical Sciences, The Univ. of Tokyo	Ph.D. Mathematics	30	6/1/2011	Stays at Kavli IPMU once a month. Joins videoconference once a month	
Toshitake Kohno	64	Professor Graduate School of Mathematical Sciences, The Univ. of Tokyo	Ph.D. Mathematics	40	10/1/2007	Stays at Kavli IPMU once a week. Joins videoconference once a week.	

Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
<u>Eiichiro Komatsu</u>	45	Director Dept. of Physical Cosmology, Max Planck Institute for Astrophysics	Ph.D. Theoretical Physics (Cosmology)	20	2/1/2008	Stays at Kavli IPMU twice a year. Joins videoconference once a month.	Attended a research project's meeting as one of the representatives and did research discussions with the collaborators at the Kavli IPMU.
Kai Uwe Martens	56	Principal investigator, Associate Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Experimental Neutrino Physics, Dark Matter Direct Detection	80	10/1/2008	Usually stays at Kamioka Branch.	
Shigeki Matsumoto	47	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Theoretical Physics (Cosmology)	80	10/1/2010	Stays at Kavli IPMU full time.	
Shigetaka Moriyama	50	Professor Kamioka Observatory, Institute for Cosmic Ray Research, The Univ. of Tokyo	Ph.D. Experimental Physics (Neutrino Physics)	20	2/1/2008	Usually stays at Kamioka Branch.	
<u>Hitoshi Murayama</u>	56	MacAdams Professor of Physics and Center for Japanese Studies, University of California, Berkeley Professor, Principal investigator Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Particle theory, Cosmology	20	10/1/2007	Stays 20% at Kavli IPMU, and 80% at UC Berkeley of which a half of the time at Kavli IPMU Berkeley satellite.	Organized 4 international workshops, invited 4 young researchers for 1 week as speakers of the Berkeley Week and invited a professor for a week as one of speakers of international workshop.
Masayuki Nakahata	60	Professor ICRR, The Univ. of Tokyo	Ph.D. Astroparticle physics	40	10/1/2007	Usually stays at Kamioka Branch.	

Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
Hiraku Nakajima	58	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Mathematics	35	4/1/2018	Stays at Kavli IPMU full time.	
Mihoko Nojiri	57	Professor KEK	Ph.D. Theoretical Physics (Particle Theory)	20	10/1/2007	Stays at Kavli IPMU twice a week.	
<u>Yasunori Nomura</u>	46	Director, Berkeley Center for Theoretical Physics, Univ. of California, Berkeley Professor, Dept. of Physics, Univ. of California, Berkeley Senior Faculty Scientist, Physics Division, Lawrence Berkeley National Laboratory	Ph. D. Theoretical Physics (Particle Theory)	15	1/1/2010	Stays at Kavli IPMU one month in a year and organizing workshops for graduate students and postdocs. Joins videoconference once a month.	Attended the WPI site visit, organized an international workshop, invited a PhD Student (20 days) from USA to do research discussion and did a public lecture at the "Kavli IPMU Public Lecture "California Scholars Forum × Boston Japanese Researchers Forum in Japan"
<u>David Spergel</u>	59	Emeritus Professor of Astrophysical Sciences Emeritus Charles A. Young Professor of Astronomy Director, Center for Computational Astrophysics, Flatiron Institute	Ph.D. Cosmology	40	10/1/2007	Stays at Kavli IPMU once a year. Joins videoconference once a month.	Encouraging researches on cosmology.
Naoshi Sugiyama	58	Professor Graduate School of Science Nagoya University	Ph.D. Cosmology	30	10/1/2007	Stays at Kavli IPMU once a month. Joins videoconference once a month.	

Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
Masahiro Takada	46	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Astronomy	80	3/1/2008	Stays at Kavli IPMU full time.	
Tadayuki Takahashi	60	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Experimental Physics	80	4/1/2018	Stays at Kavli IPMU full time.	
Yukinobu Toda	40	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. Mathematics	80	1/1/2008	Stays at Kavli IPMU full time.	
Mark Robert Vagins	54	Professor Kavli IPMU, UTIAS, The Univ. of Tokyo	Ph.D. High Energy Physics	80	5/16/2008	Stays at Kavli IPMU full time.	
Naoki Yoshida	46	Project Professor, PI Kavli IPMU, UTIAS, The Univ. of Tokyo Professor Department of Physics, The Univ. of Tokyo	Ph.D. Cosmology	40	4/1/2012	Stays at Kavli IPMU twice a week.	

Principal investigators unable to participate in project in FY 2019

Name	Affiliation (Position title, department, organization)	Starting date of project participation	Reasons	Measures taken

Appendix 3-1 FY 2019 Records of Center Activities

1. Researchers and center staff, satellites, partner institutions

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

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

Special mention

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

The Kavli IPMU proceeds to increase and rejuvenate PIs in the extension period starting from FY2017. The lineup of new PIs from FY2017 are K. Hori, K. U. Martens, S. Matsumoto, S. Moriyama, M. Takada, Y. Toda, M. Vagins, and N. Yoshida, Y. K. Kim, E. Komatsu, Y. Nomura and M. Kapranov. The new PIs from FY2018 are Hikaru Nakajima and Tadayuki Takahashi. The number of PIs has increased to 28.

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

By the end of FY 2019, we hired 21 postdoctoral researchers including 5 JSPS fellows, and 32 had left the Kavli IPMU. The hired postdocs came from different universities/institutes including UC Berkeley, University of Chicago, University of Göttingen, École Polytechnique Fédérale de Lausanne, University of Angers, University of Bonn, Johannes Gutenberg University of Mainz, Leiden University, Kavli Institute for Astronomy and Astrophysics, and Canadian Institute for Theoretical Physics, University of Tokyo, Kyoto University, Tohoku University and National Cancer Center Japan. Out of 32 postdocs who left the Kavli IPMU during FY 2019, 9 assumed faculty positions including assistant professor positions in Shanghai Jiao Tong University, in University of Pisa, in Durham University, in Centre national de la recherche scientifique, in University of Queensland, in Osaka University, in Kyoto Sangyo University, and in Okayama University and 16 moved to another postdoctoral appointment in different universities/institutes including Princeton University, Caltech, UC Santa Cruz, Flatiron Institute, University of South Dakota, University of Nebraska-Lincoln, Haverford College, Trinity College Dublin, University of Edinburgh, Università degli Studi di Milano-Bicocca, University of Melbourne, Yonsei University, National Center for Theoretical Sciences in Taiwan, Nagoya University, and Chiba 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 overseas, describe by satellite the Center’s achievements in coauthored papers and researcher exchanges in Appendix 4.

<Satellite institutions>

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

< Partner institutions >

Institution name	Principal Investigator(s), if any	Notes
Institut des Hautes Études Scientifiques (IHES)		
Institute of Physical and Chemical Research (RIKEN)		Newly added
Institute of Statistical Mechanics (ISM)		Newly added
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, KamLAND	Kunio Inoue	Newly added

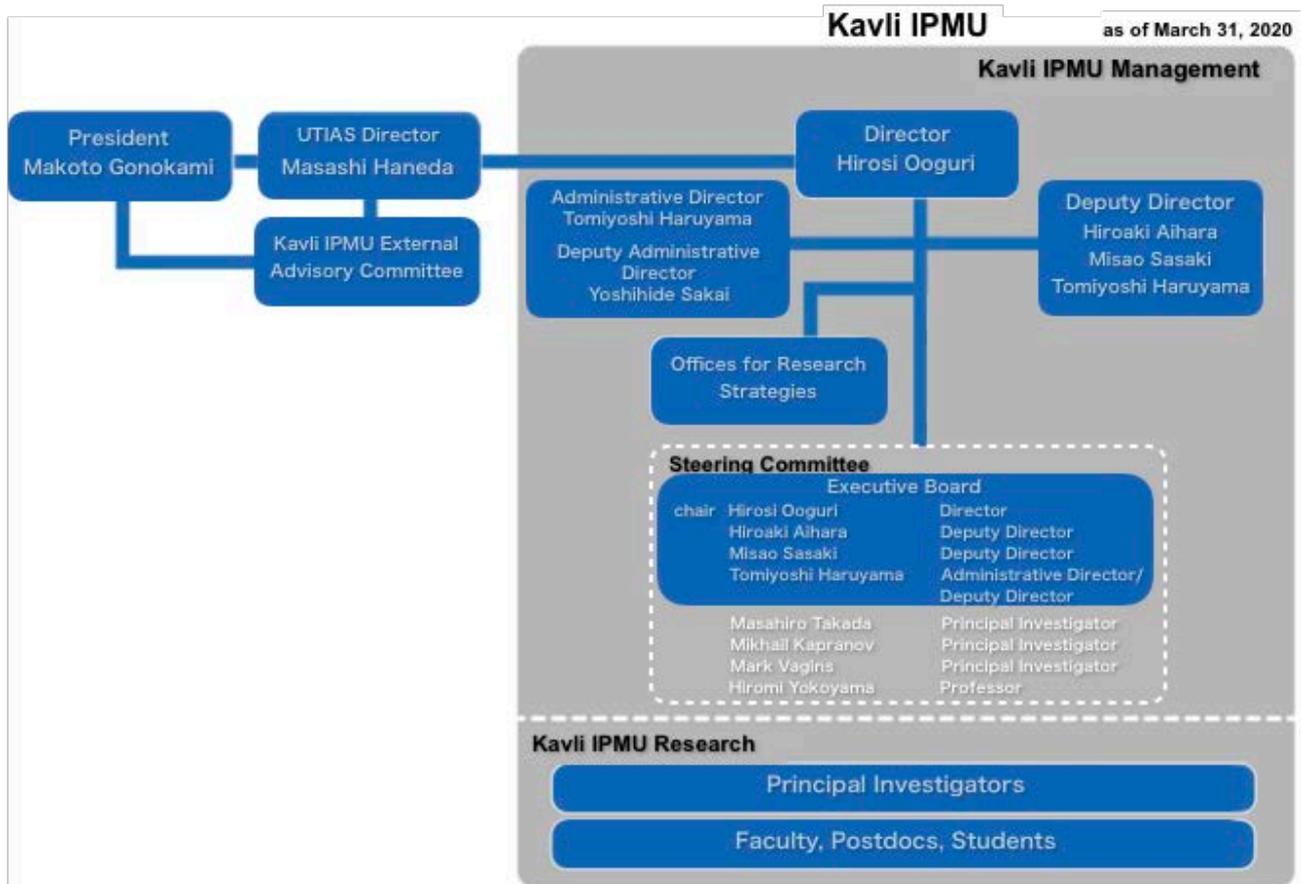
2. Holding international research meetings

- Indicate the number of international research conferences or symposiums held in FY2019 and give up to three examples of the most representative ones using the table below.

FY 2019: 18 meetings	
Major examples (meeting titles and places held)	Number of participants
14th Kavli Asian Winter School on Strings, Particles and Cosmology (Sakura Hall, Tohoku University, Miyagi, Japan)	From domestic institutions: 36 From overseas institutions: 70
East Asia Core Doctoral Forum in Mathematics 2020 (Kavli IPMU, The University of Tokyo, Chiba, Japan)	From domestic institutions: 24 From overseas institutions: 36
10th Hyper-Kamiokande Proto-Collaboration Meeting (Kavli IPMU, The University of Tokyo, Chiba, Japan)	From domestic institutions: 42 From overseas institutions: 53

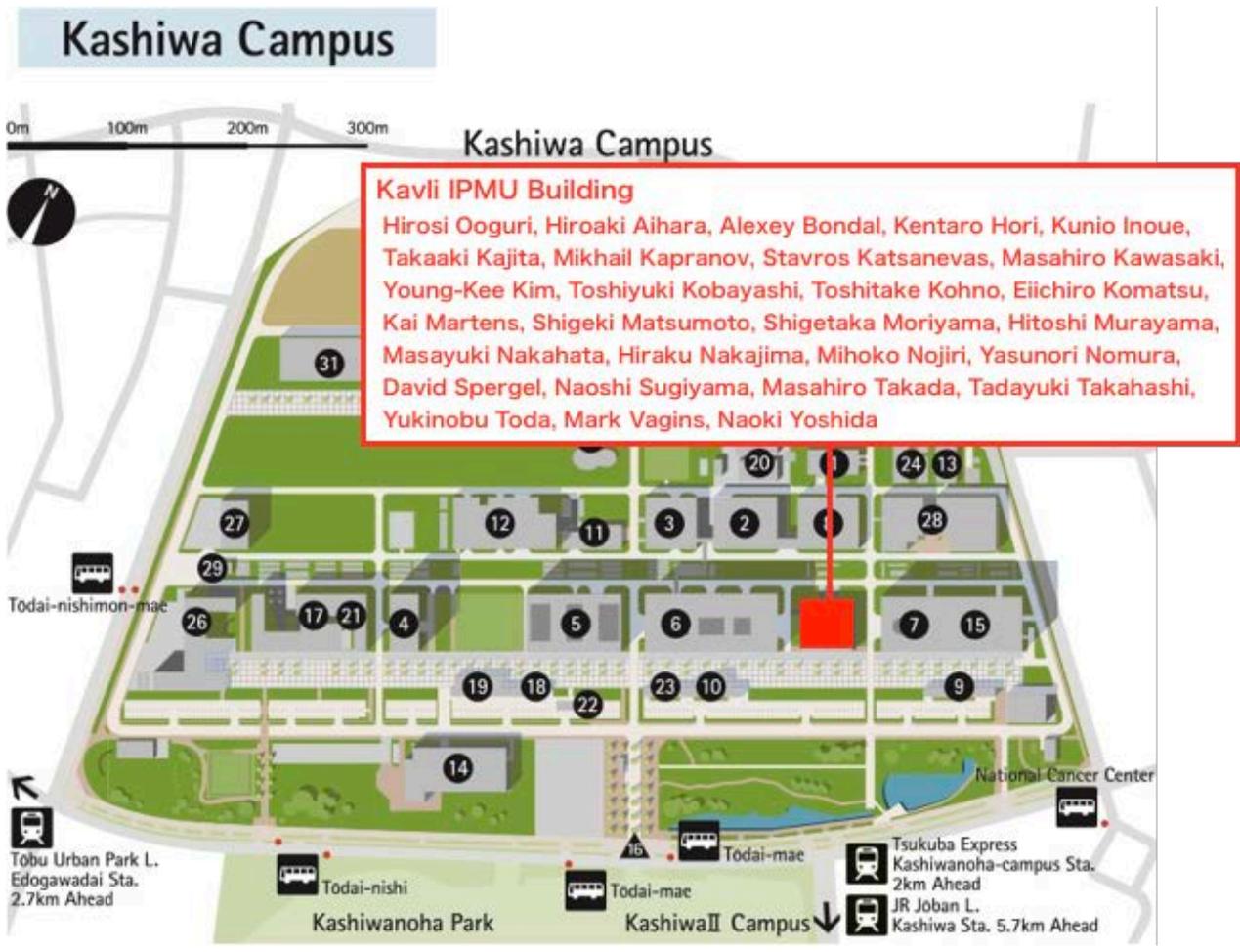
3. Diagram of management system

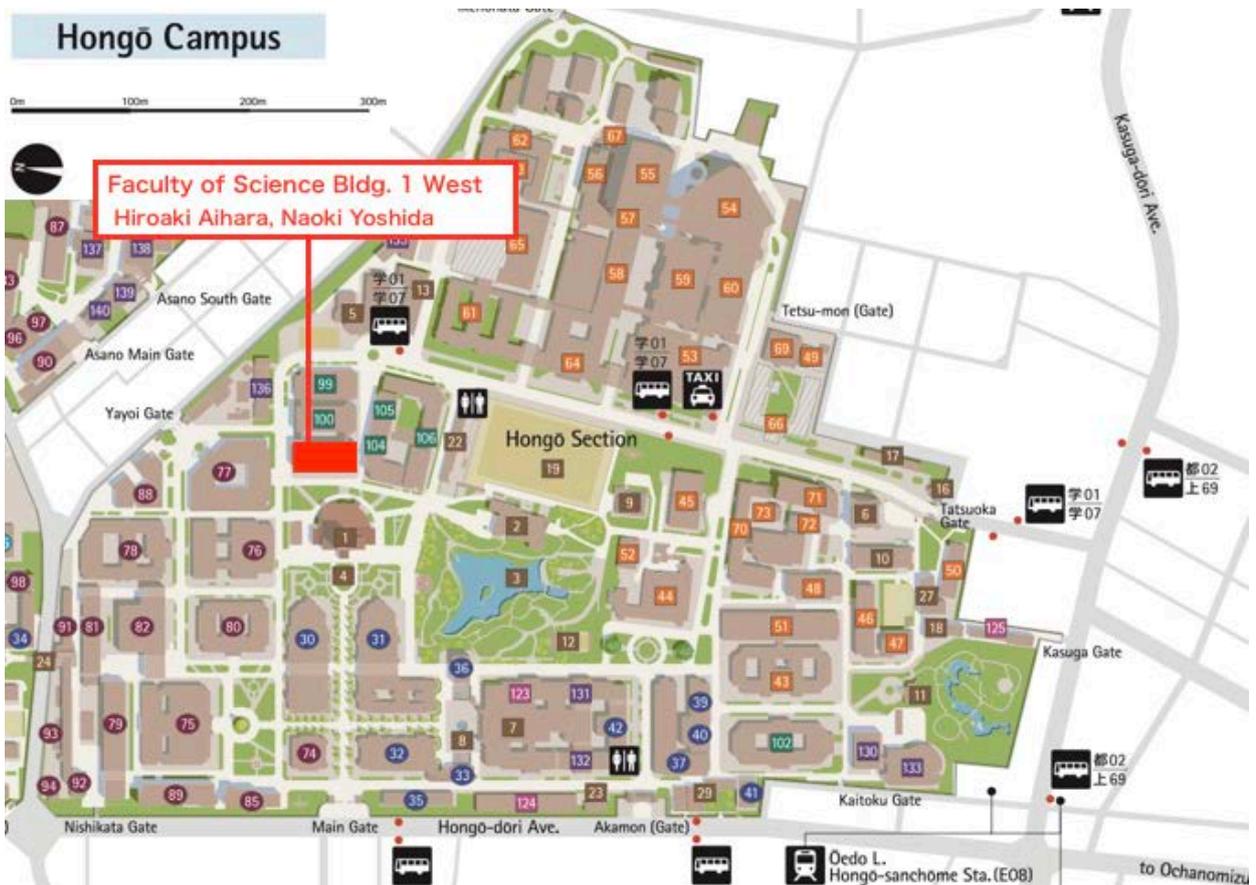
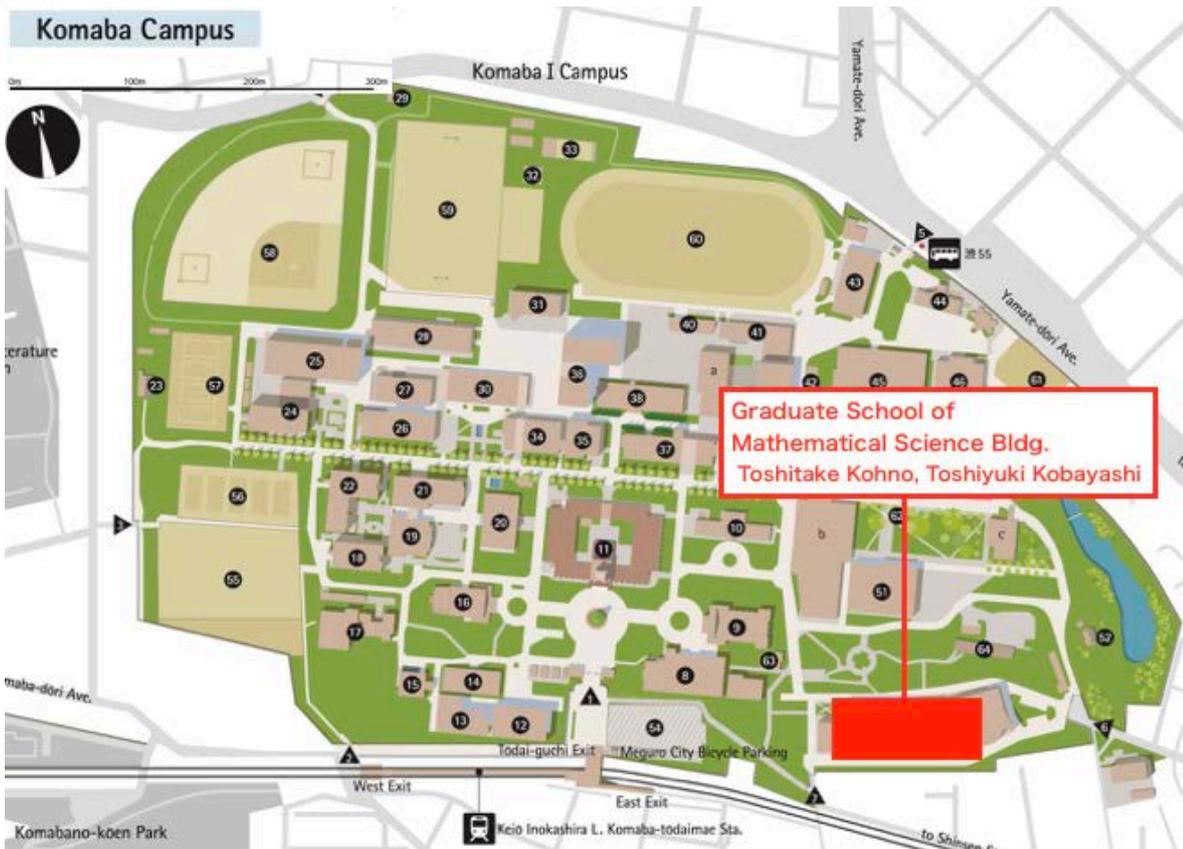
- Diagram the center's management system and its position within the host institution in an easily understood manner.
- If any new changes have been made in the management system from that in the latest "center project" last year, describe them. Especially describe any important changes made in such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

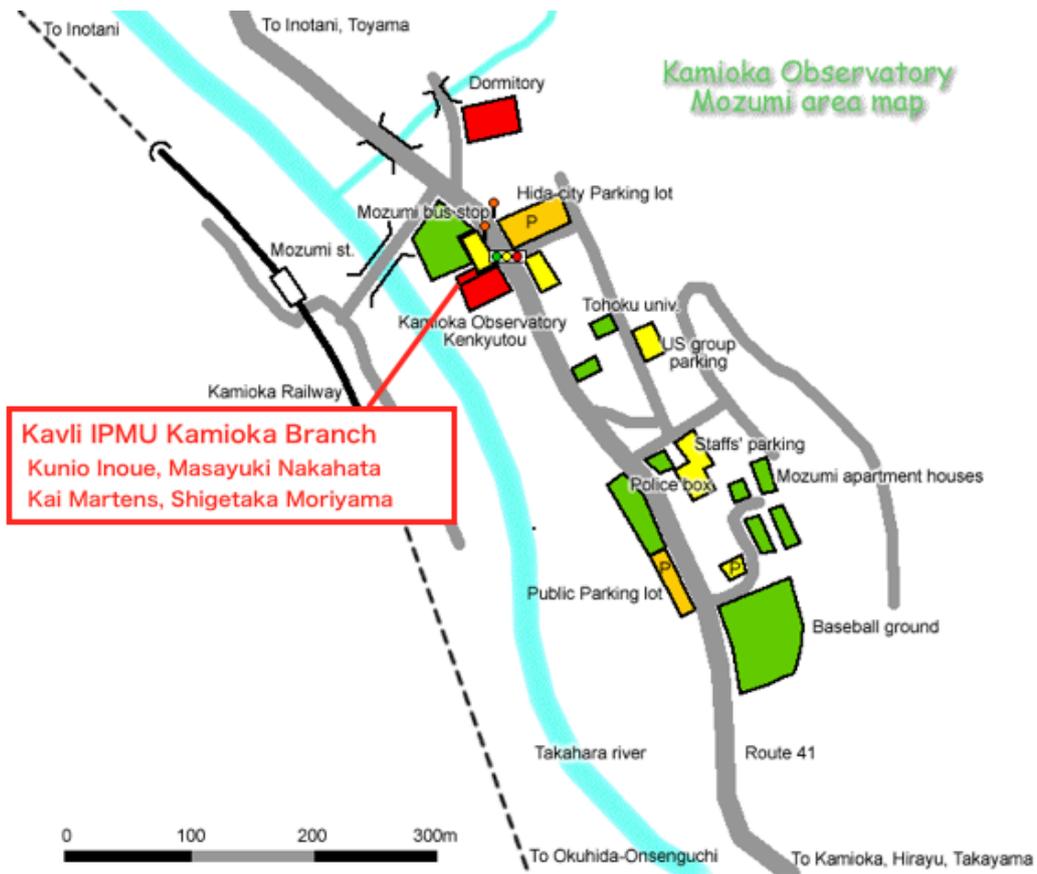


4. Campus Map

- Draw a simple map of the campus showing where the main office and principal investigator(s) are located.







5. Securing external research funding*

External research funding secured in FY2019

Total: 762,168,000 yen

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

* External research funding includes "KAKENHI," funding for "commissioned research projects," "joint research projects," and for others. (donations, etc.)

- 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–"

75,800,000 yen

- Japan Science and Technology Agency (JST)

CREST Project "Statistical Computational Cosmology with Big Astronomical Imaging Data"

16,300,000 yen

- Japan Aerospace Exploration Agency (JAXA)

"Development of polarization modulator for the LiteBIRD project"

20,000,000 yen

- Japan Society for the Promotion of Science (JSPS)

Core-to-Core Program "International Center for Observational Proof of Inflationary Universe"

15,840,000 yen

Appendix 3-1a FY 2019 Records of Center Activities

Researchers and other center staff

Number of researchers and other center staff

* Fill in the number of researchers and other center staff in the table below.

* Describe the final goals for achieving these numbers and dates when they will be achieved described in the last "center project."

a) Principal Investigators

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

(number of persons)

	At the beginning of project	At the end of FY 2019	Final goal (Date: 4, 2022)
Researchers from within the host institution	10	17	11
Researchers invited from overseas	5	8	8
Researchers invited from other Japanese institutions	3	3	3
Total principal investigators	18	28	22

b) Total members

	At the beginning of project		At the end of FY2019		Final goal (Date: month, year)	
	Number of persons	%	Number of persons	%	Number of persons	%
Researchers	18	/	280	/	213	/
Overseas researchers	5	28	118	42	83	39
Female researchers	0	0	27	10	5	2
Principal investigators	18	/	28	/	22	/
Overseas PIs	5	28	7	25	8	36
Female PIs	0	0	2	7	1	5
Other researchers	0	/	198	/	141	/
Overseas researchers	0	0	77	39	40	28
Female researchers	0	0	14	7	0	0
Postdocs	0	/	54	/	50	/
Overseas postdocs	0	0	34	63	35	70
Female postdocs	0	0	11	20	4	8
Research support staffs	0	/	29	/	28	/
Administrative staffs	3	/	11	/	10	/
Total number of people who form the "core" of the research center	21	/	320	/	251	/

Appendix 3-2 Project Expenditures

1) Overall project funding

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

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

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

(Million yens)			
Cost items	Details (For Personnel - Equipment please fill in the breakdown of fiscal expenditure, and the income breakdown for Research projects.)	Total costs	Amount covered by WPI funding
Personnel	Center director and administrative director	67	67
	Principal investigators (no. of persons):20	251	0
	Other researchers (no. of persons):132	827	338
	Research support staff (no. of persons):29	127	104
	Administrative staff (no. of persons):9	85	85
	Subtotal	1357	594
Project activities	Gratuities and honoraria paid to invited principal investigators (no. of persons):14	13	13
	Cost of dispatching scientists (no. of persons):4	5	5
	Research startup cost (no. of persons):61	38	16
	Cost of satellite organizations (no. of satellite organizations):1	14	14
	Cost of international symposiums (no. of symposiums):17	5	5
	Rental fees for facilities	6	5
	Cost of consumables	64	36
	Cost of utilities	43	41
	Other costs	223	63
	Subtotal	411	198
Travel	Domestic travel costs	12	1
	Overseas travel costs	47	8
	Travel and accommodations cost for invited scientists (no. of domestic scientists):25 (no. of overseas scientists):181	33	33
	Travel cost for scientists on transfer (no. of domestic scientists):4 (no. of overseas scientists):10	6	1
	Subtotal	98	43
Equipment	Depreciation of buildings	99	0
	Depreciation of equipment	169	59
	Subtotal	268	59
Research projects (Detail items must be fixed)	Project supported by other government subsidies, etc. ^{*1}	320	0
	KAKENHI	220	0
	Commissioned research projects, etc.	63	0
	Joint research projects	43	0
	Others (donations, etc.)	84	0
	Subtotal	730	0
Total		2864	894

The University of Tokyo -1

Costs (Million yens)	
WPI grant in FY 2019	840
Costs of establishing and maintaining facilities	0
Establishing new facilities (Number of facilities: , OO m ²)	0
Repairing facilities (Number of facilities: , OO m ²)	0
Others	0
Costs of equipment procured	62
High-precision Germanium-based semiconductor detector (Number of units:1)	13
Pulse tube refrigerator (Number of units:1)	5
Others	44

*1. Management Expenses Grants (including Management Enhancements Promotion Expenses (機能強化経費)), subsidies including National university reform reinforcement promotion subsidy (国立大学改革強化推進補助金) etc., indirect funding, and allocations from the university's own resources.

*2 When personnel, travel, equipment (etc.) expenses are covered by KAKENHI or under commissioned research projects or joint research projects, the amounts should be entered in the "Research projects" block.

*1 運営費交付金(機能強化経費を含む)、国立大学改革強化推進補助金等の補助金、間接経費、その他大学独自の取組による学内リソースの配分等による財源
*2 科研費、受託研究費、共同研究費等によって人件費、旅費、設備備品等費を支出している場合も、その額は「研究プロジェクト費」として計上すること

Kavli IPMU
Appendix 3-2

2) Costs of satellites

(Million yens)			
Cost items	Details	Total costs	Amount covered by WPI funding
Personnel	Principal investigators (no. of persons):0	/	/
	Other researchers (no. of persons):2		
	Research support staff (no. of persons):0		
	Administrative staff (no. of persons):0		
	Subtotal		
Project activities	Subtotal	1	1
Travel	Subtotal	0	0
Equipment	Subtotal	0	0
Research projects	Subtotal	0	0
Total		14	14

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Kavli IPMU

Appendix 4 FY 2019 Status of Collaboration with Overseas Satellites

1. Coauthored Papers

- List the refereed papers published in FY 2019 that were coauthored between the center's researcher(s) in domestic institution(s) (include satellite institutions) and overseas satellite institution(s). List them by overseas satellite institution in the below blocks.
- Transcribe data in same format as in Appendix 1. Italicize the names of authors affiliated with overseas satellite institutions.
- For reference write the Appendix 1 item number in parentheses after the item number in the blocks below. Let it free, if the paper is published in between Jan.-Mar. 2020 and not described in Appendix 1.

Overseas Satellite 1 Berkeley (Total: 14 papers)

No.	Author names and details
13	TARDIS. I. A Constrained Reconstruction Approach to Modeling the z similar to 2.5 Cosmic Web Probed by Ly alpha Forest Tomography <i>Horowitz, B</i> ; Lee, KG; <i>White, M</i> ; Krolewski, A; Ata, M ASTROPHYSICAL JOURNAL 887(1), 61, DEC 10, 2019
15	The Nature of Ionized Gas in the Milky Way Galactic Fountain Werk, JK; Rubin, KHR; Bish, HV; Prochaska, JX; <i>Zheng, Y</i> ; O'Meara, JM; Lenz, D; Hummels, C; Deason, AJ ASTROPHYSICAL JOURNAL 887(1), 89, DEC 10, 2019
40	Cross-correlation of CMB Polarization Lensing with High-z Submillimeter Herschel-ATLAS Galaxies Faundez, MA et al. (including <i>Cheung, K</i> ; <i>Chione, Y</i> ; <i>Goeckner-Wald, D</i> ; <i>Lee, AT</i>) ASTROPHYSICAL JOURNAL 886(1), 38, NOV 20, 2019
47	Direct limits on the interaction of antiprotons with axion-like dark matter Smorra, C et al. (including <i>Budker, D</i>) NATURE 575(7782), pp.310-314, NOV 14, 2019
60	The POLARBEAR Fourier transform spectrometer calibrator and spectroscopic characterization of the POLARBEAR instrument Matsuda, F et al. (including <i>Cheung, K</i> ; <i>Chinone, Y</i> ; <i>Goeckner-Wald, D</i> ; <i>Lee, AT</i> ; <i>Richards, PL</i>) REVIEW OF SCIENTIFIC INSTRUMENTS 90(11), 115115, NOV, 2019
127	Mapping Quasar Light Echoes in 3D with Ly alpha Forest Tomography Schmidt, TM; Hennawi, JF; Lee, KG; Lukic, Z; Onorbe, J; <i>White, M</i> ASTROPHYSICAL JOURNAL 882(2), 165, SEP 10, 2019
132	Dark matter phonon coupling Cox, P; Melia, T; <i>Rajendran, S</i> PHYSICAL REVIEW D 100(5), 55011, SEP 9, 2019
142	Evidence for the Cross-correlation between Cosmic Microwave Background Polarization Lensing from Polarbear and Cosmic Shear from Subaru Hyper Suprime-Cam Namikawa, T et al. (including <i>Chinone, Y</i> ; <i>Ali, A</i> ; <i>Beckman, S</i> ; <i>Cheung, K</i> ; <i>Corbett, L</i> ; <i>Crowley, KT</i> ; <i>Goeckner-Wald, D</i> ; <i>Groh, J</i> ; <i>Hill, CA</i> ; <i>Jeong, O</i> ; <i>Lee, AT</i> ; <i>Mangu, A</i> ; <i>Murayama, H</i> ; <i>Zhou, U</i>) ASTROPHYSICAL JOURNAL 882(1), 62, SEP 1, 2019
170	What does inflation say about dark energy given the swampland conjectures? <i>Chiang, C</i> ; Leedom, JM; <i>Murayama, H</i> PHYSICAL REVIEW D 100(4), 43505, AUG 2, 2019
258	Overview of the DESI Legacy Imaging Surveys Dey, A et al. (including Beechert, J;) ASTRONOMICAL JOURNAL 157(5), 168, MAY, 2019

278	Cosmology from cosmic shear power spectra with Subaru Hyper Suprime-Cam first-year data Hikage, C et al. (including <i>Murayama, H</i>) PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN 71(2), 43, APR, 2019
426	Learning to predict the cosmological structure formation He, SY; <i>Li, Y; Feng, Y; Ho, S</i> ; Ravanbakhsh, S; Chen, W; Poczos, B PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 116(28), pp.13825-13832, JUL 9, 2019
	Concerning Higgsinos using soft displaced tracks <i>Fukuda, H</i> ; Nagata, N; Oide, H; Otono, H; Shirai, S PHYSICAL REVIEW LETTERS 142(10), 101801, MAR 11, 2020
	Testing the seesaw mechanism and leptogenesis with gravitational waves <i>Dror, JA</i> ; Hiramatsu, T; Kohri, K; <i>Murayama, H</i> ; White, G PHYSICAL REVIEW LETTERS 124(4), 041804, Jan 28, 2020

2. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY 2019. 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: Berkeley

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2019	15	7	0	0	22
	10	0	0	0	10

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2019	2	2	0	0	4
	0	0	0	0	0

Appendix 5 FY 2019 Visit Records of Researchers from Abroad

* If researchers have visited/ stayed at the Center, provide information on them in the below table.

Total: 555

*The major 10 of 555 visitors from abroad are listed below.

	Name	Age	Affiliation		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)
			Position title, department, organization	Country				
1	Shrinivas R. Kulkarni	63	George Ellery Hale Professor of Astronomy & Planetary Sciences Professor of Astronomy, Caltech	USA	Ph.D. (Astronomy)	Dan David Prize (2017) Member, National Academy of Sciences (2003) Fellow, Royal Society, London (2001) Fellow, American Academy of Arts and Sciences (1994) NSF Alan T. Waterman Prize (1992) Helen B. Warner Prize, American Astronomical Society (1991)	2020/11/9-24	Short term stay for joint research
2	David Robert Morrison	64	Distinguished Professor of Mathematics and Physics, University of California, Santa Barbara	USA	Ph.D. (Mathematics)	Fellow of the American Mathematical Society, 2013 Fellow of the American Physical Society, 2014 Elected to the American Academy of Arts and Sciences, 2015	2019-5/24-31	Short term stay for joint research
3	Natalia Ivanova		Assistant Professor Physics Department, University of Alberta	Canada	Ph.D. (Astrophysics)	Canada Research Chair in Astronomy and Astrophysics(2009-) Tremaine Fellowship (2007-2008) Overseas Research Student (ORS) Award (1998-2001)	2020/1/17-26	Speaker of International Workshop and Colloquium
4	Andrew Fabian	72	Professor Institute of Astronomy, University of Cambridge	UK	Ph.D. (Astronomy)	Dannie Heineman Prize for Astrophysics (2008) Gold Medal of the Royal Astronomical Society (2012) Bruce Gold Medal (2016)	2019/5/12-14	Colloquium Speaker
5	Shirley Ho		Group Leader Flatiron Institute	USA	Ph.D. (Astrophysics)	Emmy-Noether Fellowship, 2015 Carnegie Science Award, 2015 Macronix Prize, 2014	2019/5/25	Colloquium & Seminar Speaker
6	Anatael Cabrera		Director LNCA Underground National Laboratory	France	Ph.D. (Particle Physics)	NSERC International Review Committee (2015) European Physics Society (EPS-HEP): "Neutrino Section Committee" (2013)	2019/11/27	Special Seminar Speaker
7	Roger Blandford	70	Professor of Physics Stanford University	UK	Ph.D. (Astronomy)	Helen B. Warner Prize (1982) Dannie Heineman Prize for Astrophysics (1998) Eddington Medal (1999) Gold Medal of the Royal Astronomical Society (2013)	2019/10/16-18	Speaker of International Workshop and Special seminar
8	Jeffrey A Newman		Professor Department of Physics and Astronomy University of Pittsburgh	USA	Ph.D. (Astrophysics)	DOE Early Career Award (2010) Mary Elizabeth Uhl Prize (2000)	2019/11/17-21	Speaker of International Conference
9	Kyle Dawson		Professor Department of Physics and Astronomy University of Utah	USA	Ph.D. (Physics)	External Reviewer for NASA (Postdoc Fellowships, time allocation for Keck Telescope) Referee (Astrophysical Journal, Astronomy and Astrophysics, Reports on Progress in Physics, Astronomical Journal, Monthly Notices of the Royal Astronomical Society)	2020/2/15-24	Invited Speaker of Research Conference
10	Michael Pevzner		Professor Director of Reims Mathematics Laboratory (UMR 9008 CNRS) University of Reims Champagne-Ardenne	France	Ph.D. (Physics)	Editor of Journal of Lie Theory	2020/1/25-30	Organize an International workshop

Appendix 6 FY2019 State of Outreach Activities

* Fill in the numbers of activities and times held during FY2019 by each activity.

* Describe the outreach activities in the "6. Others" of Progress Report, including those stated below that warrant special mention.

Activities	FY2019 (number of activities, times held)
PR brochure, pamphlet	10
Lectures, seminars for general public	36
Teaching, experiments, training for elementary, secondary and high school students	11
Science café	9
Open houses	1
Participating, exhibiting in events	3
Press releases	20
Others (Lectures for experts in specific areas, graduate students, elementary school teachers etc.)	13

* If there are any rows on activities the center didn't implement, delete that (those) row(s). If you have any activities other than the items stated above, fill in the space between parentheses after "Others" on the bottom with the name of those activities and state the numbers of activities and times held in the space on the right. A row of "Others" can be added, if needed.

Outreach Activities and Their Results

List the Center's outreach activities carried out in FY 2019 that have contributed to enhancing the brand or recognition of your Center and/or the brand of the overall WPI program, if any, and describe its concrete contents and effect in narrative style. (Where possible, indicate the results in concrete numbers.)

Examples:

- As a result of using a new OO press-release method, a OO% increase in media coverage was obtained over the previous year.
- By holding seminars for the public that include people from industry, requests for joint research were received from companies.
- We changed our public relations media. As a result of using OO to disseminate information, a OO% increase in inquiries from researchers was obtained over the previous year.
- As a result of vigorously carrying out OO outreach activity, ¥OO in external funding was acquired.

Kavli IPMU researchers delivered many public lectures listed above at different places including foreign countries such as Ludwig Maximilian Universität (Germany), Royal Nonesuch Gallery (USA), Hamburg Planetarium (Germany), Springer Nature Campus (UK) and Institute for Basic Science (South Korea).

Social Network Service (SNS) Usage

• Facebook

- Kavli IPMU (account name: KavliIpmu): www.facebook.com/KavliIpmu (since September 2009)
As of March 23, 2020, a total of 77 Facebook posts have been published on the Kavli IPMU page. More than 90 per cent of the posts have been read by 1000 users.
The most popular post was about the world's first image of a black hole, captured by the Event Horizon Telescope project, which includes Kavli IPMU visiting senior scientist Shiro Ikeda. The post has been read by 4003 users, and received 280 likes.
Other significant posts include Kavli IPMU Director Hiroshi Ooguri and MIT Assistant Professor Daniel Harlow's paper regarding symmetry, which reached 3624 users and received 243 likes, and Kavli IPMU Principal Investigator Hitoshi Murayama's TV show appearance on "The Last Lecture", which reached 3821 users and received 175 likes.

• Twitter

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

- Blog

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

Publications: Books for general public

Researchers from the Kavli Institute for the Physics and Mathematics of the Universe have published several books.

- Best sellers

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

Published September 2010, Gentosha Inc.

331,000 copies published, 8364 downloads

“What is Gravity? (重力とは何か?)” by Hiroshi Ooguri

Published May 2012, Gentosha Inc.,

149,000 copies published, 21,124 downloads

“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.

112,300 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.,

70,200 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.,

47,000 copies published

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

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

Published January 2012, Shueisha Inc.

30,500 copies published

“Strong Forces and Weak Forces: Unlocking the Magic that the Higgs Particle has Cast on the Universe

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Appendix 7 FY 2019 List of Project's Media Coverage

* List and describe media coverage (e.g., articles published, programs aired) in FY2019.

	Date	Types of Media (e.g., newspaper, magazine, television)	Description
1	April 4, 2019	Nikkei Shimbun (newspaper)	"Focus: Ken'ichi Nomoto awarded prize by the American Physical Society" (news about Senior Scientist Ken'ichi Nomoto receiving the Hans Bethe Prize by the American Physical Society)
2	April 19, 2019	NHK General (TV)	"Don't Sleep Through Life! About Baseball's First Pitch and What Is Gravity" (Director Hiroshi Ooguri gave an expert explanation about gravity to a general audience)
3	April 19, 2019	Nikkei Shimbun (newspaper)	"Science Agora: University of Tokyo Kavli IPMU Principal Investigator chases the identity of dark matter" (An indepth article about Principal Investigator Hitoshi Murayama's research paper and press release "Dark Matter May be Hitting the Right Note in Small Galaxies")
4	April 20, 2019	The Open University of Japan Channel (TV)	"Professor Yoneya's world of Super String Theory - Part 2 - The developments and future of super string theory" (Director Hiroshi Ooguri explains developments in superstring theory and its future expectations)
5	May 1, 2019	Mathematics Today (magazine)	"Let's Make a Math Museum!" (Column about a mathematics museum supervised by Professor Yukari Ito)
6	May 6, 2019	Nikkei Shimbun (online)	"Achieving results by bringing mathematics and physics together - UTokyo Kavli IPMU director" (Interview with Director Hiroshi Ooguri)
7	May 30, May 31, June 4, June 5, June 17	Yahoo! News, AstroArts, Nikkei Shimbun, Shinbun Akahata (online, newspaper)	"Researchers identify 1800 supernovae around Sextans constellation in 6 months" (news about research paper publication by Professor Naoki Yasuda)
8	June 18, 2019	SNMMI TV (online)	"National Cancer Center, Japan" video of research results, created by the Society of Nuclear Medicine & Molecular Imaging, USA. (video features Japan's National Cancer Center and work by Kavli IPMU researchers to adapt gamma-ray imaging technology to medical research, and includes an appearance by Project Researcher Miho Katsuragawa)
9	June 19, July 23	Science Daily, Bioengineer.org, Before It's News (online)	"Researchers find quantum gravity has no symmetry" (news about research paper publication by Director Hiroshi Ooguri)
10	July 11, 2019	SankeiBiz (online)	Researchers working at top space research institute must follow one rule: stop for afternoon tea at 3pm
11	July 26, July 29, July 31	Medical Xpress, News Medical, Physics World (online)	"Under development medical camera could help cut time and cost of procedures" (news about July 24 research paper publication by Principal Investigator Tadayuki Takahashi and Project Assistant Professor Shin'ichiro Takeda)
12	July 28, 2019	NHK General (TV)	NHK Special "Space Spectacle Episode 2: Look at the Black Hole, a fixer in the space" (featured appearance by Principal Investigator Hitoshi Murayama)
13	August 11, 2019	NHK Educational (TV)	Science ZERO "Elementary School Students Take on the Mystery of the Universe" (featured appearance by Principal Investigator Naoki Yoshida)
14	August 25, 2019	Sankei Shimbun (newspaper)	"New Age (Part 8) Battle of the Universe - the future and understanding the Universe - Expectations from Japan's research" (story introducing PFS as one of the dark energy research projects. Also featured comments from Director Hiroshi Ooguri and Project Associate Professor Naoyuki Tamura)

15	August 28, August 30	Phys.org, Scienmag, Energy Daily (online)	"AI learns to model our Universe" (news about August 28 research paper publication by Project Researcher Li Yin)
16	October 1, 2019	Asian Scientist (magazine)	"Asian Scientist 100 2019 EDITION" (story about 100 top researchers selected by the publication includes Director Hiroshi Ooguri)
17	October 8, October 13	Mainichi Shimbun, Yomiuri Shimbun (online, newspaper)	"Physics Nobel Laureate Jim Peebles 'built the foundation for modern cosmology'" (story featuring comments from Principal Investigator Hitoshi Murayama) Expert explanation and comments by Principal Investigator Hitoshi Murayama featured in story about Jim Peebles receiving the 2019 Nobel Prize for Physics.
18	November 2, November 3, November 4	Mainichi Shimbun, Sankei Shimbun, Nikkei Shimbun, Nikkan Kogyo Shimbun (online, newspaper)	"2019 fall Medal of Honors list" (news about Medal of Honor with Purple Ribbon recipients, including Director Hiroshi Ooguri)
19	November 1, November 4	Caltech Today, IAS, Simons Foundation (online)	"Emperor of Japan to Bestow Medal of Honor on Hiroshi Ooguri" (news about Medal of Honor with Purple Ribbon recipient Director Hiroshi Ooguri)
20	December 10, 2019	Recruit Works (magazine, online)	"Superstring theory and Mathematics of the Universe in the 21st century" (Interview with Director Hiroshi Ooguri)
21	December 19, 2019	Mainichi Shimbun, Mainichi.jp (newspaper, online)	"Voices: Hiromi Yokoyama - University of Tokyo Professor - Working towards equality in women's activities" (news about October 17 research paper publication "Parental gender attitudes associated with Japanese girls' reduced university participation" by Professor Hiromi Yokoyama and Project Researcher Yuko Ikkatai)
22	December 19, 2019	Asia Research News (magazine)	"On the hunt for primordial black holes" (story about April 2 research paper publication "Parental gender attitudes associated with Japanese girls' reduced university participation" by Principal Investigator Masahiro Takada and graduate student Hiroko Niikura)
23	January 1, 2020	NHK General (TV)	NHK Special "10 Years After: Branch Point of the Future" (featured appearance by Professor Hiromi Yokoyama)
24	January 8, January 9, January 10	Newsweek, Business Standard, The Hans India (online)	"Cosmic Magnifying Glasses Yield Independent Measure of Universe's Expansion" (news about January 9 research paper publication "Expansion rate of the Universe calculated from gravitational lensing technique" by international collaboration H0LICOW, which includes Project Researcher Kenneth Wong)
25	January 17, 2020	Kavli News (The Kavli Foundation, online)	"'Beauty'-ful Physics" (story about Belle II experiment, which involves Kavli IPMU. Included comments from Associate Professor Takeo Higuchi)
26	February 1, 2020	NOTICES OF THE AMS (magazine, online)	"Mathematics People -Ooguri Awarded Medal of Honor of Japan" (story about Director Hiroshi Ooguri receiving the Medal of Honor with Purple Ribbon)
27	February 18, 2020	Kavli News (The Kavli Foundation, online)	"Quest to Reveal the Fundamental Laws of Nature" (story about June 19 research paper publication "Researchers find quantum gravity has no symmetry" by Director Hiroshi Ooguri. Includes comments by Ooguri)
28	February 25, 2020	Kavli News (The Kavli Foundation, online)	"Dark Emulator" (story about February 5 research paper publication "Artificial Intelligence tool developed to predict the structure of the Universe" by a team including Visiting Scientist and Kyoto University Yukawa Institute for Theoretical Physics Project Associate Professor Takahiro Nishimichi, who was also Project Assistant Professor at Kavli IPMU between 2015 and 2018, and Principal Investigator Masahiro Takada. Includes comments by Takada)
29	March 2, March 9	Phys.org, daily geek show (online)	"Researchers find string theory link in a class of complex numbers" (news about March 2 press release "Researchers find string theory link in a class of complex numbers" by Associate Professor Taizan Watari and Middle East Technical University Northern Cyprus Campus and Kavli IPMU Visiting Scientist Satoshi Kondo, who was also Project Researcher and Project Assistant Professor at Kavli IPMU between 2008 and 2014)
30	March 24, 2020	Kavli News (The Kavli Foundation, online)	"The Universe's Darkest Secrets" (story about Kavli IPMU-led project Prime Focus Spectrograph. Includes comments by Director Hiroshi Ooguri)