Progress Plan for Maintaining Academy Center Certification
World Premier International Research Center Initiative (WPI)

Host Institution	The University of Tokyo
Research Center	Kavli Institute for the Physics and Mathematics of the Universe
Host Institution Head	Teruo Fujii
Center Director	Jun'ichi Yokoyama
Administrative Director	Tomiyoshi Haruyama

Please prepare this application based on the content of your center's progress report and the progress plan you submitted for the center's final evaluation. Summarize the center's future plans with regard to the following 6 items within three A-4 pages. (Also fill out the appendices at the end of this form.)

1. Overall Image of Your Center

* Describe the Center's overall image including its current identity.

The Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) was proposed to study five interrelated, basic, yet ambitious questions about the Universe:

- How did the Universe start?
- What is the Universe made of?
- What is the fate of the Universe?
- What are its fundamental laws?
- Why do we exist?

The Kavli IPMU was founded from scratch with the WPI funding on October 1, 2007, as a unique interdisciplinary institute in the world that combines mathematics, theoretical and experimental physics, and astronomy. Since then, it has grown to an international research center of about 260 members. It has produced high impact signature papers with a clear "made in the Kavli IPMU" brand, with citation counts and the number of highly cited papers comparable to or better than world-leading institutes. We receive 800 visitors on average every year, half of them from abroad; about 650 job applications every year with more than 90% from overseas. More than 60% of the postdocs who have left the institute found faculty positions. We created an environment for strong mutual inspiration between mathematics and physics, and unexpected synergies between astronomy and mathematics as well as connections with condensed matter physics have emerged.

We proposed to carry out experimental and observational programs from accelerators, underground laboratories, and telescopes, and have launched major experimental initiatives such as HSC, XMASS, and KamLAND-Zen successfully. The interdisciplinary environment allowed us to spawn new initiatives such as SuMIRe and LiteBIRD, garnering strong international attention. Our outreach program has been highly successful and mobilized more than 69,000 people, with strong media attention providing close to two thousand instances of international coverage. We spearheaded many unprecedented achievements in system reform at the University of Tokyo, such as split appointments, merit-based salary scales, and endowment donation from a foreign foundation.

During the five-year extension period of the WPI funding, the Institute proposed 9 challenges, 5 of which are on research activities and the remaining 4 are related to management, and put them into practice as much as possible. As a result, the Kavli IPMU has made a successful transition to a permanent research institute with the support of the University of Tokyo as well as the increased fund from the Kavli foundation. Although the pandemic of Covid-19 had a huge impact on our institute, practically stopping direct international communications for a couple of years, making use of online platforms, we vigorously continued our research and have steadfastly established its position as a World Premier Institute, producing top-level research outcomes in the world and enjoying high visibility in the science community of the world. Furthermore, the Institute has highly international atmosphere with the fraction of domestic

researchers less than 45% and made a major progress toward equity, diversity, and inclusion, which we recognize a very important feature, and we continue our efforts to further promote them, trying to hire minorities.

2. Research Activities

* Describe how the center will challenge new research fields and adopt new strategies.

Within the 15 years of existence, there have been major breakthroughs in our fields. A Higgs boson was discovered at the Large Hadron Collider. The new mixing angle among neutrinos was discovered. Our senior fellow, Takaaki Kajita was awarded the 2015 Nobel Prize in physics. The fundamental lemma in the Langlands program proven by Ngô Bảo Châu used Hitchin fibration that was inspired by integrable systems in physics and formulated with algebraic geometry; it confirms our choice of geometric approach and connection to physics in "What are the fundamental laws?" On the other hand, accelerator experiments have so far been unsuccessful to discover supersymmetry (SUSY), and it is now less promising as a natural means of solving the hierarchy problem. This also illustrates the difficulty of finding new physics through conventional accelerator experiments at high energy frontiers. On the other hand, Planck's observation of cosmic microwave background (CMB) has revealed important information on the primordial curvature and tensor perturbations, constraining models of cosmic inflation. Furthermore, the first detection of gravitational waves from a black hole binary merger in 2015 marked the beginning of a new era in gravitational wave astrophysics, followed by the detection of gravitational waves from binary neutron stars in 2017, making multi-messenger astronomy a reality.

Under these circumstances, we will introduce and further develop new research directions leveraging the strengths of Kavli IPMU, namely, galaxy of splendid theorists covering from astronomy, cosmology, particle phenomenology, string theory, to mathematics and the three key experimental projects. They are Subaru Prime Focus Spectrograph, underground experiments in Kamioka, and polarization measurements of cosmic microwave background with Simons Observatory and the LiteBIRD satellite. Specifically, we introduce two new research directions: (A) Seeking new laws of nature in observations and their comprehensive theoretical studies, and (B) Multi-messenger and multi-wavelength gravitational wave science.

(A1) Planck's CMB observation suggests non-supersymmetric inflation models with modified gravity, such as the curvature square model and the Higgs inflation. These models in turn possess large dimensionless parameters much bigger than unity, which may be a hint of extra dimensions. These features can have a profound impact on fundamental physics, including string theory and mathematical studies of space-time. Furthermore, these models can be probed by the LiteBIRD. Thus, this research project will realize synergies from mathematics and string theory to cosmology and observation and will take advantage of IPMU's strengths.

(A2) Recently, Eiichiro Komatsu, a senior fellow of Kavli IPMU, has shown that the polarization angle of CMB may have changed in time. This cosmological birefringence may indicate the existence of axion fields which have major implications not only to the nature of dark matter and dark energy but also to string theory that predicts numerous species of axion. Here again we can expect synergy of fundamental physics and observations.

(A3) Observations using Subaru Prime Focus Spectrograph, one of the key projects of Kavli IPMU, nicely fits this scope, too, because this instrument, being able to measure spectra of nearly 2400 objects at one time, will provide us with invaluable information on neutrino mass, dark energy and galactic archeology.

(A4) By the same token, the big data from LSST/Vera Rubin observatory will bring us with enormous information on cosmic structure from which we can study fundamental physics of the Universe such as the properties of dark energy and modification of gravity. The newly established Center for the Data Driven Discovery (CD3) will play a central role to achieve it.

(B1) Simultaneous observations of the gravitational wave event of binary neutron star mergers in gamma rays, X-rays, visible light, to radio waves provide useful information on gamma-ray bursts and nucleosynthesis in the universe, answering to the question "Why do we exist?" The LSST can play a major role in rapid follow-up observations of gravitational wave events by taking advantage of its wide field of view and rapid response. Furthermore, Super-Kamiokande, now containing gadolinium as proposed by Kavli IPMU faculty Mark Vagins, and Hyper-Kamiokande can not only detect background neutrinos from supernova and measure CP violation in the neutrino sector with high precision, but also detect neutrino burst associated with gravitational wave events. Thus, Kavli IPMU can play important

roles in multi-messenger astronomy, and to achieve this, we develop rapid data analysis system at the Center for the Data Driven Discovery.

(B2) Just like photon-based astronomy, multi-wavelength gravitational waves convey information on various cosmic phenomena. Primordial gravitational waves extending to the Hubble scale can tell us when cosmic inflation happened, which can be measured by B-mode polarization experiments like Simons Observatory and LiteBIRD, and if we can observe those in the 1 Hertz band, we may determine when the Big Bang occurred, which is feasible by space-based laser interferometer such as DECIGO. If both LiteBIRD and DECIGO can reveal when inflation and the Big Bang occurred, it can answer the question, "How did the Universe start?" This motivates us to initiate basic research of the latter.

These science goals include synergies from mathematics and string theory to cosmology and observation for which Kavli IPMU is a unique place to realize. To make them reality, we will provide free and vigorous research environment and to stimulate cross-disciplinary discussions. We will also make efforts to expand Center for the Data Driven Discovery to deal with big data of LSST swiftly and to recruit an expert on modified gravity to meet the demands inferred from the observations.

3. System for Managing the Research Organization

* Describe the research organization and management system that the center will use to carry out the research strategy and plan described above.
* In Appendix 1-3, list the Principle Investigators, enter the number of center personnel, and provide a diagram of the center's management system.

The current management structure allows for quick decisions by the directorate for recruitments and retentions, as well as for arranging timely workshops and visitors to enhance our research. We will develop a wider "sense of ownership" of the Institute among younger members to carry the Institute into the future. We optimize top-down decisions on day-to-day management while exploit bottom-up initiatives on research agendas. The organization remains flat with no "departments" within the Institute, and the Directorate is always open to new initiatives from the individual faculty members.

We have been paying special attention to foster young researchers. We make sure that they receive sufficient exposure to secure their career paths, while learning the landscape of science on the international scene. Our policy requiring one to three months of travel a year outside Japan to promote their research with presentations and collaborations, as well as hosting a large number of workshops and visitors, has been extremely successful for this purpose. We intend our Assistant Professor positions to be tenure-track, some joint with other institutes.

We have many achievements in system reform. We take the active role of an evangelist to make these reforms permeate the system by working on other Japanese institutions to create split appointments following success of Murayama (Berkeley) and Bondal (Steklov). Our administrative staff won six President's awards for improvement in business practice, and many of them are being used widely within the University. The University of Tokyo was fortunate to institute another WPI center, International Research Center for Neurointelligence (IRCN). We will work closely with IRCN both on the scientific aspects (similarity between the large-scale structure of the universe and the network of neurons) and the administrative practice (novel hiring schemes and support for international scientists). Having two WPI centers at the same university should catalyze reform of the Japanese university system as a whole. Taking advantage of the director's strong connection to the School of Science, we will boost propagation of our system reform to the whole University.

We believe working with graduate students is a must for a world-class research institution. With Hitoshi Murayama as the program coordinator, the Institute is leading a new graduate school program in physics and mathematics entitled the Forefront Physics and Mathematics Program to Drive Transformation (FoPM) which has been selected as a MEXT WISE program. This program has enabled more IPMU faculties to take graduate students from physics department, and graduate students belonging to traditional departments are also staying at Kavli IPMU for an extended period to study in our international environment. We have established a program to bring Oxford students since 2015 and 8 students have already obtained PhD degrees. We also joined the Global Science Graduate Course (GSGC) program with which we hire a few graduate students from outside Japan annually.

We recognize diversities in both ethnic origin and gender are very important factors to make Kavli IPMU a unique place with truly international atmosphere. This is not simply a matter of number accounts; it is important to create an environment in which everyone can feel comfortable and can do their best. We will continue our efforts to maintain it and to propagate this atmosphere to the rest of the University utilizing the connection of the director with the School of Science.

The most important thing for the Kavli IPMU to do would be to demonstrate that it is worthy of public support by producing ground-breaking discoveries in science, by training and mentoring students and young scientists to become world leaders, and by propagating systems reforms throughout universities in Japan. The directorate will enable our scientific staff members to perform at the highest levels by supporting their initiatives and by providing them an ideal research environment, and to communicate their achievements to our funding agencies and the general public.

4. International Circulation of Best Brains

* Describe your policy and concrete plan for promoting the international circulation of the world's best brains, which is an important function of the WPI Academy.

From the development stage, we had a firm belief that the key to gaining international recognition is to bring top-level leaders and talented young researchers from around the world, and to create an environment in which researchers in different fields learn each other's languages and work together toward common goals. We have established such a fascinating research environment here at the Kavli IPMU. It functions as the center for the "brain circulation." In 2023, we have 24 world-leading all onsite Kavli IPMU professors (equivalent to PIs). Out of 266 member researchers including faculty members, postdoc, 124 (46%) are international and considered as world class. To keep the Kavli IPMU as a hub of exciting intellectual exchanges, we will keep inviting many Nobel laureates in Physics, Fields Medalists and prominent researchers to stimulate young researchers. Also, we keep our policy that all full-time researchers have to spend one to three months abroad each year.

We successfully recruited topnotch scientists such as M. Kapranov, a former full professor at Yale, to one of our first tenured positions. Given his well-known status as a leader in higher category theory and driver behind many important mathematical concepts recently, this is a significant boost of our international standing. His activity at the Kavil IPMU attracts the world best brains. Also we recruited M. Hartz, a neutrino experimentalist. Furthermore, as the director of the newly established Center for Data-Driven Discovery, we successfully hired Jia Liu who declined offers from two American universities.

In addition to this international brain circulation in terms of personnel, we plan to adopt the following measures to function as a Gateway to the World in the Japanese scientific community to further stimulate brain circulation in broader scope and enhance international reputations.

One is to function as a networking hub toward the realization of next-generation large-scale research projects for which international cooperation is essential. The aforementioned DECIGO can be a good example. We plan to support the cradle of such a long-term, large-scale project that is of high scientific significance but that cannot be carried out in Japan alone. In order to realize this, we would first invite the planners of such a project as an affiliate member of the Institute, host joint workshops with potential overseas partners, and proceed to the conclusion of international research cooperation. This will enable Kavli IPMU to become a driving force for international cooperation and meet the role expected of it by society. It will further help the development of the next generation of international leaders and the circulation of brains as well as introduction of overseas funding through the cooperation of international partners.

The other is to host various big international conference series in relevant fields which tours around the world, such as COSMO, PASCOS, Strings, Texas Symposium, Neutrino Conference, SUSY, GR, etc. which are good occasions to have many renowned scientists at one time; let them stay at Kavli IPMU for an extended period and organize satellite meetings in house, to communicate with domestic researchers. With Kavli IPMU being a Gateway to the World, all these events will play important roles to lead the Japanese physics, astrophysics, and mathematics communities to realize brain circulation with the rest of the world.

5. Support by Host institution

* Describe measures that the host institution will take to support and sustain your WPI center. Describe your strategy for extending the system reforms achieved by the center via the WPI program to the host institution and other institutions.

At the time of the original proposal, UTokyo made many exceptions to the Kavli IPMU as a "special district" within the University: flexible salary system, longer appointments than traditional fixed-term positions, moving some PIs with advantageous arrangements with retirements from traditional departments, appointments beyond the retirement age, etc. UTokyo also built the main research building specifically for the Kavli IPMU, and a new international lodge near the Kashiwa campus. A creation of

UTIAS in 2011 is outstanding support providing a permanent place for the Kavli IPMU within the University. Following the interim evaluation, UTokyo made several measures to make the Kavli IPMU sustainable. UTokyo guarantees 10 tenured positions, and permanent assignment of administrative staff.

UTokyo confirms that it is crucially important for the Kavli IPMU to have 26 permanent positions for the core of faculty and to keep the critical mass. System reforms originated in the Kavli IPMU are awarded UTokyo Special Prize for business innovation 6 times. Its unique measures are gradually spreading out inside UTokyo and outside.

6. Financial Measures

* In Appendix 4, describe the measures to be taken by the host institution for sustaining the center's functions and activities over a period of 5 years, and describe what external funding will be used to carry out the center's research activities.

The University of Tokyo understands that the operating resource necessary to sustain the world "leading" premier status is at least the former funding level from the WPI program. These figures are quite standard to run so-called institute of advanced study in healthy conditions. In March 2021, the University of Tokyo approved our proposal to place the university funding for the Kavli IPMU in the core expenses category, at about 1 billion yen per year. Being part of the core expenses category means that the funding is permanent. As a result of the Kavli IPMU's high visibility, and also the University's effort to sustain the Institute, the Kavli foundation boosted the endowment from USD7.5M to 17.5M. The University will keep making effort in many ways to boost the reputation of the Kavli IPMU to further increase the endowment. The Kavli IPMU and Hamamatsu Photonics K.K. established the Endowed Research Unit in 2014 for 5-year program, which was extended for another five years in 2019.

As a World Premier Institute, Kavli IPMU is an ideal organization to receive the "University Funds to realize a world-class research university". By applying for these funds, we will not only continue to achieve world-class research results, but also educate graduate students in an international environment to foster world-class human resources and play leading roles to advance basic science in Japan.

World Premier International Research Center Initiative (WPI)

List of Principal Investigators

- If the number of principal investigators exceeds 10, add columns as appropriate.
- Place an asterisk (*) by the name of the investigators who are considered to be ranked among the world's top researchers.
- Give age as of 2 July 2023
- For investigators who cannot participate in the center project from its beginning, indicate the time that their participation will start in the "Notes" column.

Name	Age	Current affiliation (organization, department)	Academic degree and current specialties	Notes (Enter "new" or ongoing")
1. Jun'ichi Yokoyama*	60	Kavli IPMU (Director)	Ph.D. cosmology	new
2. Hirosi Ooguri*	61	Kavli IPMU (Professor) California Institute of Technology (Professor, Physics Dept and Mathematics Dept., Director, Burke Institute)	Ph.D. string theory	ongoing
3. Hitoshi Murayama*	59	Kavli IPMU (Professor), University of California, Berkeley (Professor, Physics Dept)	Ph.D. particle theory, cosmology	ongoing
4. Hiroaki Aihara*	67	UTokyo (Executive Vice President, Professor, Dept of Physics), Kavli IPMU (Deputy Director)	Ph.D. high energy physics	ongoing
5. Alexey Bondal*	61	Steklov Mathematical Institute (Professor), Kavli IPMU (Professor)	Ph.D. mathematics	ongoing
6. Misao Sasaki*	70	Kavli IPMU (Deputy Director, Professor)	Ph.D. cosmology	new
7. Masashi Hazumi*	57	Institute of Particle and Nuclear Studies , High Energy Accelerator Research Organization (Professor) Kavli IPMU (Scientific Associate)	Ph.D. High Energy Physics	new
8. Simeon John Hellerman*	51	Kavli IPMU (Professor)	Ph.D. mathematics	new
9. Kentaro Hori*	57	Kavli IPMU (Professor)	Ph.D. string theory	ongoing

10. Yukari Ito*	55	Kavli IPMU (Professor)	Ph.D. mathematics	new
11. Mikhail Kapranov*	61	Kavli IPMU (Professor)	Ph.D. mathematics	ongoing
12. Shigeki Matsumoto*	50	Kavli IPMU (Professor)	Ph.D. particle theory, cosmology	ongoing
13. Todor Eliseev Milanov*	47	Kavli IPMU (Professor)	Ph.D. mathematics	new
14. Hiraku Nakajima*	60	Kavli IPMU (Professor)	Ph.D. mathematics	new
15. John David Silverman*	55	Kavli IPMU (Professor)	Ph.D. astronomy	new
16. Yuji Tachikawa*	43	Kavli IPMU (Professor)	Ph.D. string theory	new
17. Masahiro Takada*	50	Kavli IPMU (Professor)	Ph.D. astronomy	new
18. Tadayuki Takahashi*	64	Kavli IPMU (Professor)	Ph.D. experimental physics	ongoing
19. Yukinobu Toda*	43	Kavli IPMU (Professor)	Ph.D. mathematics	ongoing
20. Mark Robert Vagins	58	Kavli IPMU (Professor)	Ph.D. experimental physics	ongoing
21. Masahito Yamazaki*	40	Kavli IPMU (Professor)	Ph.D. string theory	new
22.Naoki Yasuda*	56	Kavli IPMU (Professor)	Ph.D. astronomy	new

23.Hiromi Yokoyama*	47	Kavli IPMU (Professor)	Ph.D. Science and society	New
24. Naoki Yoshida*	49	Kavli IPMU (Professor)	Ph.D. astronomy	Ongoing

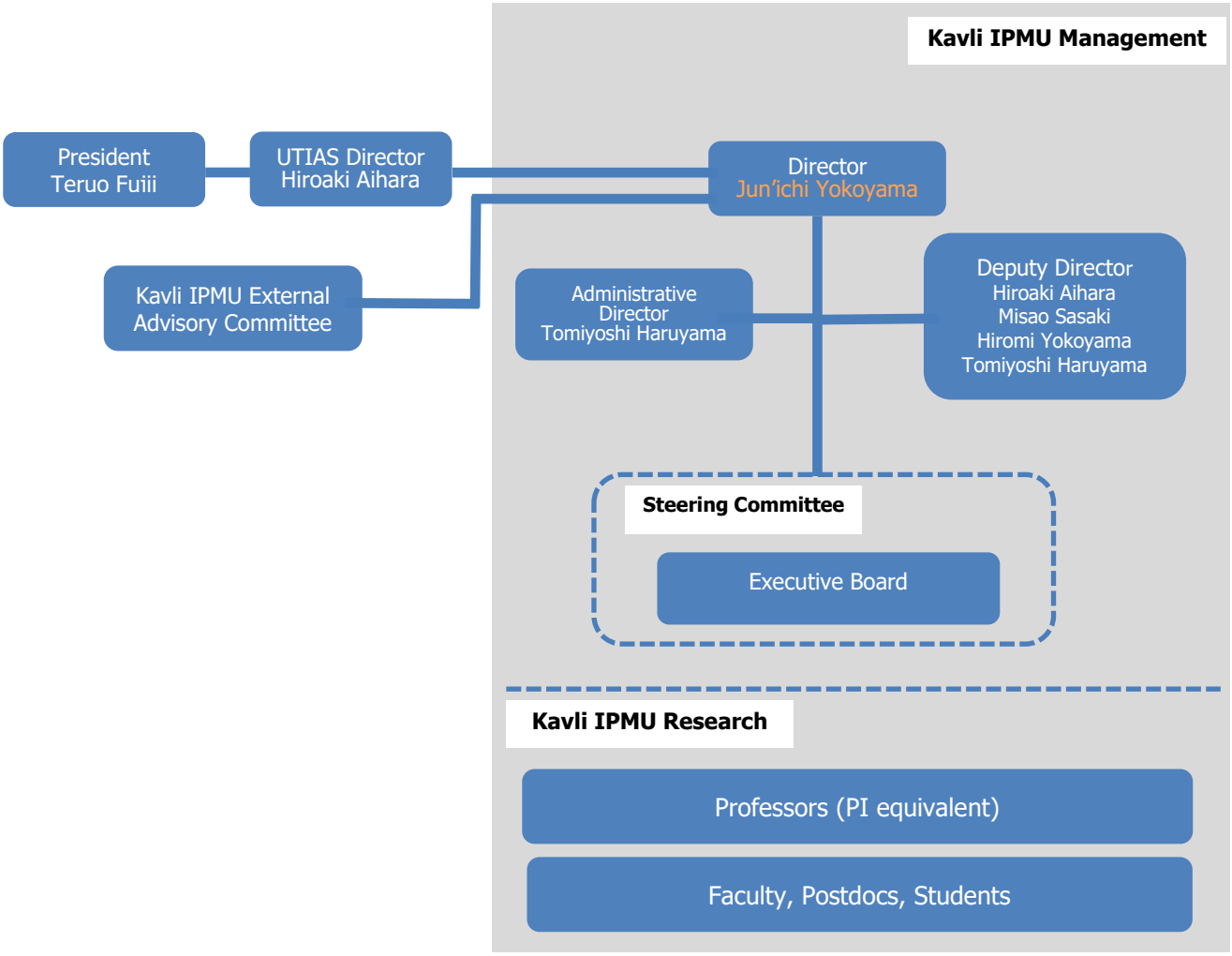
World Premier International Research Center Initiative (WPI)
Academy
The number of Center personnel

	FY2022
Principal Investigators	24
Other Researchers	187
Post-Doctor researchers	55
Research Support Staffs	28
Administrative Staffs	11

World Premier International Research Center Initiative (WPI)

Diagram of Management System

Kavli IPMU **as of October 15, 2023**



Vision Statement

Jun'ichi YOKOYAMA

Sixteen years after its foundation, the Kavli Institute for the Physics and Mathematics of the Universe has really established the status of a World Premier Institute, producing top-level research outcomes in the world, and enjoying high visibility in the science community of the world. Furthermore, it has highly international atmosphere with the fraction of domestic researchers less than 45% and made a major progress toward equity, diversity, and inclusion. It has also been regularly realizing various reform of administration and distinctive outreach activities. In short, past 16 years of Kavli IPMU has been a marvelous success.

In order for the Institute to continue to develop further, however, it is imperative to review and rearrange main research projects and to open new perspective, incorporating the advances in the physical sciences over the past 16 years. For Kavli IPMU to maintain its high reputation and continue to disseminate significant scientific results, I would like to implement the following three measures.

I. New directions of research incorporating advances in science after its foundation.
II. New measures to achieve these scientific goals.
III. Reforms to address various university issues.

I. New directions of research

Looking back at the progress in physics since Kavli IPMU was founded, the Higgs boson has been found by the Large Hadron Collider and the Standard Model of particle physics was established. However, supersymmetry, which is desired to stabilize the low energy physics of the Standard Model against quantum corrections of high energy unified theories, has yet to be discovered, and it is becoming less promising as a natural means of solving the hierarchy problem between the two energy scales. This also illustrates the difficulty of finding new physics through conventional accelerator experiments at high energy frontier. Observationally, Planck satellite reported its seminal results to measure the spectral index of primordial curvature perturbation and constrain the tensor-to-scalar ratio as well as the non-Gaussianity parameters, which provide us with useful information on particle physics model of inflation. In addition, the first detection of gravitational waves from a black hole binary merger was made in 2015, and gravitational waves from a binary neutron star coalescence were detected in 2017, making multi-messenger astronomy a reality. Most recently, Pulsar Timing Array experiments (PTA) have detected hints of stochastic

gravitational wave background which may be of cosmological origin.

Under these circumstances, I propose to boldly introduce new research directions leveraging the strengths of Kavli IPMU, namely, galaxy of splendid theorists covering from astronomy, cosmology, particle phenomenology, string theory, to mathematics, as well as the three key projects of the institute, or Subaru Prime Focus Spectrograph, underground experiments in Kamioka, and polarization measurements of cosmic microwave background in terms of the Simons Observatory and the LiteBIRD satellite. Specifically, I would like to implement the following two directions.

(1) Seeking new laws of nature in observations and their comprehensive theoretical studies. Planck's observations of the cosmic microwave background radiation suggest non-supersymmetric inflation models with modified gravity, such as the curvature square model and the Higgs inflation. These models in turn possess large dimensionless parameters much bigger than unity instead of small parameters, which are unacceptably large in the commonsense of particle physics, and their origin should be clarified. These features can have a profound impact on fundamental physics, including string theory and mathematical studies of space-time. Just as Einstein constructed general relativity with the help of Marcel Grossman a hundred years ago, cooperation with mathematicians may be the key to solve the problem, and the environment of Kavli IPMU is ideal to accomplish it. Furthermore, these models can be probed by Simons Observatory and LiteBIRD.

Another important recent claim is the possible discovery of cosmological birefringence, namely, time variation of the polarization angle of the cosmic microwave background radiation. This analysis has been led by a senior fellow of Kavli IPMU. If this observation is verified correct, it will have major implications for the nature of dark matter and dark energy. It will also have a big impact on the string theory that predicts numerous species of axions. This phenomenon can also be observationally probed by radio galaxies emitting jets, around which linearly polarized photons are emitted. So far only giant jet emitting radio galaxies have been analyzed by astronomers, but there are much more numerous smaller radio galaxies yet to be analyzed. By statistically analyzing these numerous data at the newly established Center for the Data Driven Discovery (CD3), we will certainly be able to obtain important implication on the axion physics.

Furthermore, observations using Subaru Prime Focus Spectrograph, one of the key projects of Kavli IPMU, nicely fits this scope, because this instrument, being able to measure spectra of nearly 2400 objects at one time, will provide us with invaluable information on neutrino mass, dark energy and galactic archeology, as well as on the modification of gravity beyond Einstein. By the same token, the big data from LSST/Vera Rubin observatory will bring us with enormous information on cosmic structure from which we can study

fundamental physics of the Universe such as the properties of dark energy and modification of gravity. The Center for the Data Driven Discovery will play a central role to achieve it.

(2) Multi-messenger gravitational wave astrophysics and cosmological gravitational wave physics. Simultaneous observations of the gravitational wave event of binary neutron star mergers in gamma rays, X-rays, visible light, to radio waves have opened a new era of multi-messenger astrophysics and provided useful information on gamma-ray bursts and nucleosynthesis in the universe. The LSST can play a major role in rapid follow-up observations of gravitational wave events by taking advantage of its wide field of view and rapid response. Furthermore, Super-Kamiokande and Hyper-Kamiokande can detect neutrino bursts associated with gravitational wave events such as supernova explosion. In cooperation with RESCEU, which is the center of data analysis of LIGO-Virgo-KAGRA gravitational wave network in Japan, Kavli IPMU can play very important roles in multi-messenger astrophysics to lead the first simultaneous detection of photons and neutrinos from gravitational wave events, and we should prepare real-time analysis of LSST data at the CD3.

Just as photon-based astronomy has developed over a variety of wavelengths and each wavelength conveys information about various celestial objects, gravitational waves at different wavelengths yield information on a wide variety of cosmic phenomena. Among them, primordial gravitational waves generated during inflation period and extending to the Hubble scale can tell us when cosmic inflation happened, which is the science target of Simons Observatory and LiteBIRD, and if we can observe those in the 1 Hertz band, we may determine when the Big Bang occurred. The latter is feasible through the DECIGO project being developed in Japan, which is a far-reaching plan that requires international cooperation. If both LiteBIRD and DECIGO can reveal when inflation and the Big Bang occurred, it will provide definitive information on the early evolutionary history of the Universe, which is one of the primary goals of Kavli IPMU.

The above science goals include synergies from mathematics and string theory to cosmology and observation. To achieve them, it is important to provide free and vigorous research environment and to stimulate cross-disciplinary discussions. Daily teatime meetings, which have been a feature of Kavli IPMU, certainly help to stimulate such activities. To further promote collaboration more systematically, I would like to organize a networking lunch where people with different expertise and different generation share a table to chat over a lunch. Similar events have been held in the meetings of LIGO-Virgo-KAGRA collaboration and I found them very useful. At every topical workshop organized at the institute, I would also like to propose to have a gathering of participants and members of the institute to promote interaction between people with different areas of expertise. For the

data analysis of both observational cosmology and multi-messenger astrophysics, it is desirable to further expand Center for the Data Driven Discovery to deal with much larger data than originally anticipated and develop more rapid analysis method to meet the requirements of the latter, about which machine learning and AI will be helpful and I would like to seek for cooperation with the Beyond AI institute of the University in this respect.

II. New measures to achieve these scientific goals

As described above, gravity is the key to solving the mystery of the Universe, so it is desirable to augment researchers specializing in gravitation. However, it is not straightforward to secure new positions at Kavli IPMU for this purpose, which has matured as an institute maintained by funds mostly from the University of Tokyo. I hope to reverse this trend and bring new researchers by introducing new schemes of employment that will further promote international brain circulation. This new arrangement is an international cross-appointment, whereby those employed by it will have stronger obligations than the current affiliate member system. They are required to stay at the institute for an agreed minimum duration such as a few months each year and may be engaged in graduate student education. If this scheme works well, it will not only further promote brain circulation but may also develop a double degree program, leading to further university reform.

Another measure I propose is for Kavli IPMU to function as a Gateway to the World in Japanese scientific community, as it has established the status of a World Premier Institute and is highly regarded in the global scientific community. Using its high reputation, I propose Kavli IPMU to function as a networking hub toward the realization of next-generation large-scale research projects for which international cooperation is essential. The aforementioned DECIGO is a good example. I propose that Kavli IPMU support the cradle of such a long-term, large-scale project that is of high scientific significance but that cannot be carried out in Japan alone. In order to realize this, we would first invite the key planners of such a project as an affiliate member of the Institute, host joint workshops with potential overseas partners, and proceed to the conclusion of international research cooperation. This will enable Kavli IPMU to become a driving force for international cooperation and meet the role expected of it by society. It will further help the development of the next generation of international leaders and the circulation of brains as well as introduction of overseas funding through the cooperation of international partners.

I also propose Kavli IPMU to host various big conference series of the relevant fields annually which tour around the world, such as COSMO, GR, Texas Symposium, PASCOS, Strings, SUSY, ICHEP, Neutrino conference etc. In recent years, China and Korea are organizing many of them, while not so much in Japan. If a big institute like Kavli IPMU

would not host them, they would never happen in Japan, reducing the presence of Japanese science. They are good occasions to invite many renowned scientists at one time; let them stay at Kavli IPMU for an extended period and organize satellite meetings in house, to communicate with domestic researchers. With Kavli IPMU being a Gateway to the World, all these events will play important roles to lead the Japanese physics, astrophysics, and mathematics communities to realize brain circulation with the rest of the world.

This spirit should also apply to the daily activities of the Institute including workshops and other meetings.

III. Reforms to address various university issues

Kavli IPMU has been implementing various institutional reforms, and I would like to take advantage of the fact that I am also affiliated with the Graduate School of Science to make an effort to spread these reforms throughout the University. Kavli IPMU has been treated as a "special district" in the University, and I propose to use it as a test bench to explore new directions for reform such as introduction of reverse auctions in procurement, after carefully understanding the actual situation at the Institute.

One problem that Japanese universities have in common is the issue of diversity; Kavli IPMU has been working on this issue and I would like to take it further. Just before my term as the president of the Association of Asia Pacific Physical Societies (AAPPS) was over, I determined the code of conduct of AAPPS which includes: (Clause 2) The activities of AAPPS shall be planned and conducted with integrity, respect, fairness, trustworthiness, and transparency; (Clause 3) The activities of AAPPS shall be free from discrimination based on such factors as ethnic origin, religion, citizenship, language, political or other opinion, gender, sexual orientation, or disability. These are much the same as the code of conduct of Kavli IPMU determined by the current director except that ours intentionally omitted age as a factor, because we wish to favor younger generation toward the future. I recognize diversities in both ethnic origin and gender are very important factors to make Kavli IPMU a unique place with truly international atmosphere where everyone can feel at home.

As for the gender equity, I understand there are three steps to proceed. The first step is a situation where a small number of women are struggling in a male-dominated society. The second step is a state with a significant number of women who play active roles without hesitation. The third step is a state in which there are a significant number of women in top management leading the organization. The traditional departments in School of Science are still in the first step, while Kavli IPMU is in the second step now. To further promote to the third step, I would like to hire a female administrative director if I am appointed as director.

Another problem we may overcome is the barriers among faculties, departments, and

institutes in the university. I organized a steering committee meeting of RESCEU as its director, which was attended by dean of School of Science, director of Institute for cosmic ray research, chair of physics department, and former chair of astronomy department. They unanimously agreed to allow me to continue as director of RESCEU while my term continues, even if I assumed director of Kavli IPMU, to further cooperate to break among them. Once this is achieved, cooperation between Kavli IPMU, School of Science and Institute for Cosmic Ray Research will be very smooth. Of course, breaking barriers is one thing but not everything; what is important is the science we create together by breaking them. Multi-messenger gravitational wave astrophysics is the ideal theme to achieve by breaking the barriers among three sectors for the University of Tokyo to lead the science of the world.

Breaking internal barriers is also important to improve gender equity issue, as it is often the case that the spouse of female researchers is also a researcher in the same or related fields. We would like to work across departmental barriers to resolve the two-body problem of dual carrier academic couples. The new hiring scheme I am proposing to promote international brain circulation would be helpful to achieve it.