Report of the review committee for
Department of Physics
Research Center for the Early Universe
Universal Biology Institute
Institute for Physics of Intelligence
Quark Nuclear Science Institute
School of Science
The University of Tokyo

東京大学理学部・大学院理学系研究科
物理学科・物理学専攻
ビッグバン宇宙国際研究センター
生物普遍性研究機構
知の物理学研究センター
クォーク・核物理研究機構
に関する
外部評価委員会報告書

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Report of the review committee for Department of Physics, Institute for Physics of Intelligence, Research Center for the Early Universe, Universal Biology Institute, Quark Nuclear Science Institute

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The purpose of this external review is to assess the present status of activities of the Department of Physics at the University of Tokyo (dubbed "the Department" below), thereby making recommendations for future directions to develop into an outstanding center at an international level. The committee especially focused on Research, Undergraduate and graduate course programs, Management, Internationalization, Social collaboration programs, and Diversity of staff and students.

As detailed below, the Department is globally recognized as one of the world's top universities in both research and education. First, the research activities are extremely high with all faculty members playing leading roles in their respective fields. The undergraduate and graduate educational programs are well organized at a sufficiently high level, establishing a solid foundation for nurturing the next generation of researchers. Furthermore, the Department's management works very well, ensuring high-level research and an excellent educational environment. Regarding internationalization, the Department is evaluated as being at an excellent level in terms of personnel exchange, collaborative research with overseas institutions, etc. It is also appreciated that the Department has made extensive efforts in social relations and cooperation with private companies. Concerns include the gender imbalance and the issue of diversity among international faculty and students, both of which should be addressed urgently. Furthermore, as already stated in the 2019 report, the space at the Hongo campus is inferior to that of many other universities in Japan. The committee strongly recommends the university administration to allocate more resources for the Department to reach its full potential.

In conclusion, the committee highly commends all the activities of the Department mentioned above and suggests their continuation and further development. To achieve this, continued support from the University of Tokyo for budget, space, etc. is essential.

February, 2026

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Table of Contents

Report of the review committee for
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THE DEPARTMENT AS A WHOLE

INDIVIDUAL RESEARCH FIELDS

THE DEPARTMENT AS A WHOLE

1. Education

1-1. Undergraduate Course Education

The main objective of undergraduate education is for all students to learn standard and fundamental physics in a variety of fields. For this purpose, the lectures are well organized. A semester of the 2nd grade and the 3rd grade fully covers fundamental physics courses, which are enriched with the related exercises and laboratory works. In particular, good opportunities are provided for students to access faculty on an individual basis. For example, seminar style courses are scheduled in the 3rd grade, in which a group of 4 students learn or discuss specific topics in physics under the supervision of a professor that they select. The Department colloquium, held every one or two months, provides the students with a good opportunity to learn cutting-edge research topics and also think about their future direction in research. If possible, having an AI-related lecture for undergraduate students could be suggested. It is very impressive that the Department supports various activities that are planned by students themselves, which are typically seen in the event in the May Festival of the University of Tokyo.

The committee had an opportunity to talk with nine undergraduate students (eight 4th-year and one 3rd-year students) and three of them are female. All nine students are enjoying student life. They are also highly motivated to pursue graduate research, with eight of them hoping to continue to PhD programs. Regarding the space, there are student common rooms, making it easy for students to interact with others. They are satisfied with this environment. The undergraduate course lectures and seminars are well organized and very helpful in choosing a lab. They said that about 30% of students participate in the physics colloquium, which is helpful in learning about specialized topics.

One concern is the extremely low proportion of female students. Special care may be necessary for female students and international students who tend to be isolated. In order to make a female-friendly environment, it is useful to give a lecture on gender issues to the students and the faculty members. For example, it is important to know what micro-aggression is and what unconscious bias is.

1-2. Graduate Course Education

The main objective of graduate course education is to increase the knowledge and understanding of students in various fields of physics so that they can tackle unresolved problems not only in academic fields but also in many aspects of industry and society. The graduate course program is well organized for this purpose, which particularly respects the balance between course work and research in each group. Every year, about 110–120 new students, a number quite large compared with that of any other university in Japan, enter the Master course, and approximately half of them come from outside the undergraduate course of the University of Tokyo. Accordingly, the Department offers a variety of course work so that they can choose the most appropriate course efficiently. All lectures are provided in English if there is at least one student who cannot understand Japanese. Research-oriented education is done in individual research groups under the guidance of the advisor, giving the important opportunities for students to learn the latest progress and discoveries in their own research field and perform their own original work.

Research activities of graduate students are extremely high, as typically exemplified by many published papers (about 120 papers for 2019-2025) in high-quality journals. These data show that this Department plays a vital role in nurturing the next-generation researchers. As mentioned in the financial support issue below, it is very impressive that the number of students who proceed to the PhD course has risen to 70%. This figure is notably high, implying that the graduate program of the Department works very well.

The committee had an opportunity to talk with six graduate students (three master’s students, three doctoral students (one female)). All of them are highly motivated and positive about their research. For their future prospects, they aspire to become researchers, and many are considering whether to remain in academia or look for work more broadly, including industries, etc. Financially, the PhD students are satisfied with support from JSPS, JST, and the University of Tokyo's graduate programs. Also, they highly appreciate a very good environment provided by the Department where their research can be conducted freely. One of the improvements they want is to make student common rooms, which are important for stimulating interaction among students across laboratories. Many students hope to gain overseas experience in the future. As in the case of the undergraduate course, diversity issues such as gender inequality are also important in graduate schools and need to be improved in the future.

1-3. Graduate Course Programs and Financial Support

The leading graduate program of MEXT was launched in 2011, which aims to develop human resources with PhD degrees who will be potential leaders not only in academic fields but also across a wide range of society. The proposal of the Department of Physics together with the Department of Applied Physics and the Department of Chemistry for “photon science leading graduate course” (ALPS) was approved in 2011, and furthermore two other programs for the material science area (MERIT) and for the mathematical science (FMSP) were approved in 2012, in both of which the Department of Physics is involved as a major partner. These programs have been used very efficiently for enhancing graduate course activities: for example, the number of students who proceed to PhD courses increased up to 70%. Although the programs already ended, the University of Tokyo is continuously supporting the course students, and the programs have been succeeded by the WINGS program. Another piece of good news is that three new programs for Takuetsu Daigakuin, launched by MEXT in 2018, were approved:

(1) Forefront Physics and Mathematics Program to Drive Transformation (FoPM) in coordination with Kavli IPMU, Faculty of Mathematical Science and Faculty of Engineering

(2) International Graduate Program for Excellence in Earth-Space Science (IGPEES): interdisciplinary educational program that further develops the field of astrobiology

(3) World-leading Innovative Graduate Study Program for Quantum and Semiconductor Science & Technology Program (WINGS-QSTEP)

Thanks to these graduate programs, students can pursue doctoral studies without financial anxiety. Furthermore, the recent favorable employment situation in industry appears to have reduced concerns about life after earning a doctorate. As a result, the number of doctoral students is increasing. This is a favorable situation for the Department. Capitalizing on this advantage, the Department is expected to cultivate many outstanding researchers.

These graduate course programs have also played an important role in broadening students' research perspectives, encouraging them to take on new fields, and broadening their career paths. The committee also appraises that these programs are quite efficient in enhancing the internationalization of graduate students through dispatch to overseas universities and research institutes, international internships, etc. One concern that the committee would like to raise is how to ensure the resources for the graduate programs described above. To maintain high-quality education, we urge the Department of Physics to maintain or even further improve the conditions. It is also important to recruit excellent students to the PhD course and actively accept international students.

2. Research and Hiring Policy

This Department is operated under a structure that places the core chairs on the Hongo Campus at the center of undergraduate education, while also incorporating affiliated and cooperative chairs in other departments and on other campuses within the university, as well as in external research institutions, thereby covering a wide range of research fields from the fundamentals to advanced and interdisciplinary areas.

The self-evaluation report (2025) states that there are approximately 130 professors, associate professors, and lecturers involved in graduate education and research supervision, of whom 42 belong to the core chairs (as of November 2025). Since 2019, new research organizations in such areas as physics of intelligence, quantum science, and nuclear science have been established in sequence, thereby expanding the institutional base for advanced and interdisciplinary fields.

Regarding the promotion and hiring of PIs, the general external review report (2026) clearly states that, even when a vacancy is anticipated, the same field is not automatically refilled; rather, the process begins with an open call for field proposals, which is examined by the Long-Term Planning Committee as necessary, and proceeds to open recruitment and selection after a vote at the faculty meeting. Promotion from associate professor to professor is generally reviewed approximately every two years, with achievements and future plans being examined, while in some cases the selection process may be accelerated depending on the circumstances. It is also explicitly stated that internal promotion from assistant professor or lecturer to associate professor or higher is strictly prohibited.

As for the assistant professor system, this Department's policy is to maintain the current system in light of heavy operational burdens unique to Japanese universities (including the large volume of duties other than research) and financial constraints. Lecturers are positioned as so-called senior assistant professors who play a role in promoting research, while also serving as a stepping stone toward promotion or transfer to positions outside the Department. This committee also examined the appropriateness of the current assistant professor and lecturer system.

2-1. Evaluation

Rather than relying on the simple replacement of vacant positions, the framework of strategically initiating open recruitment through field proposals, after examining future needs and the present allocation of fields, is reasonable for responding to the growth of interdisciplinary areas and changes at the research frontier, and it also ensures transparency in the process. The flexible system for internal promotion of associate professors can also be positively evaluated from the standpoint of stimulating activities within the Department. Over the past six years, the Department has maintained a balanced operation, with six professors hired from outside and three promoted internally.

Regarding the assistant professor system, the external review report (2019), while raising issues concerning the institutional design, also pointed out the advantage in theoretical fields that younger researchers can more easily concentrate on research. In an environment where operational burdens and financial constraints are substantial, this committee considers that the current system has a certain degree of rationality from the perspective of enabling the quick and smooth operation of research units while securing research time for younger researchers.

Accordingly, this committee concludes that maintaining the present system is appropriate, while noting that sufficient consideration must be given to the future career paths of assistant professors and lecturers.

At the same time, the more strongly the current system is maintained, the more indispensable it becomes to develop institutional mechanisms for reducing non-research burdens. The directions set forth in the general external review report (2026)—namely reducing time spent on duties other than research, assigning specialized research support personnel such as URAs, and introducing a research leave system—are important for enhancing the effectiveness of the system.

2-2. Recommendations

(1) Make visible the actual burdens of non-research duties (such as teaching, administration, applications, and safety management), and establish indicators for annually reviewing the extent to which research time is being secured.

(2) Achieve the placement of research support staff as the highest-priority measure, and institutionalize it in a form that includes division of duties, evaluation, and retention. In light of financial constraints, relatively flexible sources of funding, such as donations and support funds, should be allocated with priority to strengthening the research support system.

(3) Make it routine, from the field-proposal stage onward, to identify female and overseas candidates, thereby strengthening diversity and internationalization in recruitment.

(4) Since shortages in research space directly affect recruitment, the Department should clearly specify the research space and facilities that can be provided at the time of appointment. Broader issues of space planning and development will be addressed in the Management section.

3. Management

Regarding the budget, the external review report (2019) pointed out that, under the continuing reduction of government funding for national universities, additional revenue sources are necessary to maintain the standards of education and research. While external funds have been secured at a scale exceeding the university's operating budget, the report explicitly noted that restrictions on their use for education and administration, as well as year-to-year fluctuations, make long-term planning difficult. The general external review report (2026) also indicates that the university's operating budget is used mainly for administration, utilities, and education, while research activities depend on external funds such as Grants-in-Aid for Scientific Research, and that the Faculty of Science Physics Support Fund (launched in January 2025) has been established.

Regarding space, the external review report (2019) stated that the current floor area remains at only about 67% of the officially allocated area, and that securing adequate space is indispensable as a basic condition for research and education. The self-evaluation report (2025) shows that, under a total floor area of 9,932 m^2 (compared with an allocation of 15,656 m^2), the standard space for experimental laboratories is limited to 200 m^2 per laboratory, which is insufficient for experimental work, and the shortage of space is becoming an issue in faculty recruitment; it also indicates that it is difficult to secure adequate space for student common rooms and similar facilities. As challenges to be addressed, the report mentions consideration of shared research space (open labs) and the use of common lecture rooms.

Regarding gender equality and diversity, the external review report (2019) stated that the diversity of faculty and students is important given the uncertainty about the future. The general external review report (2026) indicates that, when proposing fields for PI recruitment, there is a requirement to include information on female and overseas candidates when necessary, and it also summarizes recruitment achievements, including assistant professor positions reserved only for women, as part of efforts to improve diversity. It further explicitly identifies strengthening internationalization, i.e., diversity among students and staff, and curricula taught in English, as part of the future plan. The self-evaluation report (2025) also presents data on the acceptance of international students and their increases and decreases, showing that the number of international students at the graduate level has been increasing.

3-1. Evaluation

In terms of financial resources, the Department has a strong ability to secure external funding, but as pointed out in the external review report (2019), such funding comes with restrictions on its use for education and administration, and is also subject to large annual fluctuations. Under a structure in which the operating budget is used mainly for administration, education, and utilities, it is important to secure flexible financial resources and a mechanism for allocating them so that fundamental expenses—such as common equipment and facility maintenance, educational support, and support for early-career researchers and students—can be covered stably.

The shortage of space directly affects not only the vitality of research and the learning environment for students, but is also an issue from the perspective of faculty recruitment, as explicitly stated in the self-evaluation report (2025). The gap from the officially allocated space has already been shown numerically, and therefore the issue requires not merely annual short-term adjustments, but a response that combines shared use, operational improvements, and a medium- to long-term development policy.

Regarding gender equality and diversity, the system of requiring information on female and overseas candidates at the field-proposal stage, together with the establishment of assistant professor positions reserved for women, can be positively evaluated as institutionalized efforts. At the same time, it is important to take a medium- to long-term perspective of steadily building diversity as a research and educational organization through not only recruitment, but also the internationalization of curricula and the continuous improvement of diversity among students and staff. During the six years of the evaluation period, four women were hired as assistant professors, two of whom were appointed through channels other than women-only recruitment. In particular, the fact that the University of Tokyo hired a woman as an assistant professor in the theoretical field through an equal evaluation process is likely to have a major impact on other universities. The committee hopes that, going forward, due consideration will continue to be given to diversity in personnel decisions, including the hiring of PIs.

3-2. Recommendations

(1) While maintaining the Department's strength in securing external funding, systematically expand revenue sources with fewer restrictions on their use for education and administration (such as support funds, donations, and industry collaboration), and secure “core operating funds” to stably support common equipment, facility maintenance, and TA/RA support.

(2) On the assumption that external funding fluctuates from year to year, establish a multi-year spending plan (including priorities and procedures for reductions), and develop a form in which responses to the 2019 concern that long-term planning is difficult can be shared and implemented within the Department.

(3) Clarify the plans to create shared research space (open labs) and to use common lecture rooms, including room-allocation criteria, operational procedures, and implementation timing. Document them so that “research space and facilities available after appointment” can be clearly presented at the time of faculty recruitment. At the same time, incorporate a plan to improve student space into the implementation plan. Although the current shortage of space affects all members in the Department, the establishment of common space for graduate students—which was particularly strongly requested by students—would have high cost-effectiveness, and the committee strongly hopes that this can somehow be realized through various creative ideas.

(4) Make it mandatory to submit information on female and overseas candidates at the field-proposal stage as a routine in the candidate searches, and connect initiatives such as women-only assistant professor positions to a continuous pipeline of personnel development and promotion. Internationalization measures already in place, such as offering courses in English,

should also be further enhanced according to needs and developed in an integrated manner together with educational management and support.

4. Internationalization

Regarding internationalization, the Department is judged to be operating at a high level in personnel exchange, collaborative research with overseas institutions, and initiatives for the development of young researchers. In each of these areas, active and sustained efforts are evident. The department has organized a substantial number of international conferences and has also contributed original sessions to major international meetings. For example, the Trans-scale Quantum Science Institute hosted four international symposia with more than 200 participants and organized three sessions accepted at international conferences during the evaluation period. These activities indicate the presence of a significant number of faculty members capable of taking leading roles in international academic initiatives and demonstrate a level of international engagement consistent with the department's research strength.

International personnel exchange is also being carried out at a commendable level. The number of foreign researchers among the postdoctoral staff ranged from three to nine per year. Since the total number of postdoctoral researchers, excluding DC1 and DC2 researchers, is between 30 and 70, this implies that at least 10% of postdoctoral researchers are international. This should be regarded positively from the standpoint of both diversity and the cultivation of young researchers. In addition, the gravitational wave group, centered on the KAGRA project, is inherently based on international collaboration, and frequent international exchanges of personnel are therefore a natural and important feature of its activity. The effective use of bilateral exchange programs between Japan and France, as well as participation in the NEXUS Japan-Singapore joint research project in quantum science, is also worthy of note. Furthermore, the IPI regularly organizes international seminars and symposia, while the UBI hosted 14 visiting researchers from abroad in 2024 alone, which appears substantial given the scale of the institute.

Particularly noteworthy is the extent to which internationalization has been incorporated into policies for the training of young researchers. Through the DAIKIN Advanced Interdisciplinary Research (AIR)-Vision Mobility Grant (2025–), the IPI has established concrete measures to promote overseas dispatch and personnel exchange as part of its support framework for early-career researchers. Another example is provided by Professor Satoshi Nakamura's service as Chair of the Advisory Committee and Organizing Committee for the Joint International School, the 13th Strangeness Nuclear Physics School, and the 23rd CNS Summer School (SNP-CNS SS 2024). These activities reflect a clear commitment to the development of young researchers through international educational and research opportunities. This commitment is not limited to graduate students and postdoctoral researchers; the operation of overseas dispatch programs for undergraduate students is also highly valuable. Such international course programs at the undergraduate level are important from the perspective of fostering the next generation of globally engaged researchers.

In addition, although not discussed in detail here, many researchers in the department contribute to the international academic community through editorial service for journals in their respective fields. Taking these points together, the department may be evaluated as having achieved a high standard of internationalization.

5. Social Collaboration Programs

Since the advances in science and technology enrich our society, the application of university research results to issues of public and social interest is also highly expected through industry-academia collaboration supported by industry-funded programs. Physics is one of the most important foundations supporting scientific and technological innovation. The Department has enormous intellectual resources. By utilizing this resource through industry-academia collaboration, the Department may contribute to our society. In this context, it is timely to have social collaboration programs in the Department.

While explicit outreach/industry collaboration was limited in 2005, following the recommendation of stronger external communication with industry and other communities in 2012 and stronger visibility (website updates, open-campus style outreach) in 2019, the Department initiated several social collaboration programs during the past 5 years. They include:

(1) Study of “Magnetic and Electronic Properties at Interface”, with Nitto Denko Corporation, from 2021 to 2028, with faculty advisers of Prof. S. Nakatsuji and T. Higo, for the purpose of “Fabrication of high-quality thin films of topological magnets and development of heat flux sensing and spintronics”,

(2) Study of “Topological Materials & Device Innovation Course”, with JSR Corporation, from 2022 to 2026, with faculty advisers of Prof. S. Nakatsuji, H. Idzuchi, K. Tanaka, and S. Minami, for the purpose of “Research and device development of Weyl magnets for practical implementation of quantum technology”, and

(3) Study of “Topological Quantum Sensing”, with Alps Alpine Co., Ltd., from 2024 to 2029, with faculty advisers of Prof. S. Nakatsuji and A. Fukushima, for the purpose of Beyond Magnetoresistance (MR) - Enhancing resolution through novel effects in topological materials.

Great care was taken in structuring the collaboration so as to preserve independence and creative education/research while maintaining university autonomy, assigning faculty members to lead the programs, and enabling company researchers to participate as collaborative researchers. The committee admires these social collaboration programs undertaken by the Department.

In addition, the Department initiated the Trans-Scale Quantum Science Institute, with many overseas partners of Princeton University, Johns Hopkins University, University of California, University of British Columbia, Max Planck Institute, and École normale supérieure, CEA/CNRS -Paris -SACLAY/Grenoble , from 2020 to 2030, for the purpose of "Exploring the full spectrum of quantum science", "Building the global research platform", and "Developing strategic plans for research training". This program is supported by several external grants of JST ASPIRE, JST AdCORP with overseas universities, JST Mirai, NEDO with companies, NEDO(TopoLogic) with startups.

Furthermore, the Department initiated the Comprehensive Collaboration ("CURIE") between U Tokyo Physics and JSR (since 2020), with the organizational structure of Steering Committee (Department Chair + JSR R&D Executive), R&D Division, and Collaboration Strategy Office. This includes joint research launched under separate agreements, annual workshops and lecture series with invited researchers, and student support: JSR Fellowship and "Challenge Research Call" for early-career researchers from 2025.

All of the above programs are being successfully conducted. Therefore, in order to sustain and further develop these successful social and international collaboration programs both now and in the future, it is essential to secure adequate physical space and to establish a robust institutional foundation, including a professional research administration system with appropriate expertise. The responsibility for providing these conditions should not rest solely with the Department; rather, it must be assumed proactively by The University of Tokyo as a whole.

In recent years, it has been particularly significant that Japanese companies—often perceived as prioritizing short-term returns—have committed themselves to supporting fundamental physics research at the Department from a long-term perspective. This engagement is of strategic importance for strengthening Japan's scientific and technological foundation. Moreover, the expansion of collaborations with leading international research institutions is indispensable for maintaining and enhancing the Department's global competitiveness.

However, under the current Japanese university system, researchers are required to manage a wide range of administrative responsibilities themselves, including contract management, external funding applications and reporting, intellectual property procedures, and coordination with external partners. This structure consumes a substantial portion of researchers' time and severely limits their ability to concentrate on research. As industry and international collaborations expand, this burden is expected to increase further.

The Department's social and international collaboration programs have already produced tangible results and are expected to grow further. Accordingly, their continued development should not depend solely on the Department's internal efforts. The University of Tokyo should advance, in an integrated manner, both the necessary infrastructure development and the strengthening of research support systems, thereby establishing an institutional environment in which researchers can devote themselves fully to research.

Researchers' time is the most valuable resource of the University. Allowing it to be eroded by excessive administrative burdens directly leads to a decline in research capability and international competitiveness. Proactive and timely action by the University leadership is indispensable for maximizing the Department's achievements and further enhancing the global standing of The University of Tokyo as a whole.

6. New Organization

This section evaluates the centers, institutes, and programmatic platforms that have been added to, or operate in close affiliation with, the Department of Physics and that materially shape the Department's research breadth, education, and external interfaces. As baseline context, the 2019 External Review emphasized the growing importance of organizational-level industry-academia collaboration and described the establishment of the Institute for Physics of Intelligence (IPI) as timely, while recommending broader corporate engagement and stronger public communication. The 2019 review also identified structural risks, especially space constraints, and warned that, if not carefully attended, such constraints could erode the Department's ability to sustain leadership.

The committee supports the Department's strategy of creating and expanding new organizations to broaden research scope and strengthen quality, and understands that such structures can be necessary to secure budgets and faculty positions in a financially constrained environment. This strategic expansion is consistent with the Department's own framing of physics as increasingly intertwined with AI, biology, and quantum information/technology. Several platforms demonstrate credible early achievements and outward-facing connectivity, including international partnerships, consortium-style collaboration, and structured education/training. At the same time, the committee highlights three cross-cutting concerns:

(1) Administrative burden is a real drawback. New organizations inevitably introduce additional coordination, reporting, and event/consortium management work. If this burden is not professionalized, it can disrupt research and reduce the net benefit of organizational expansion.

(2) Governance and feedback loops are not sufficiently visible. Some committee members could not clearly identify what Department-level deliberations preceded establishment of each new

organization, nor how outcomes are evaluated and fed back into Department strategy. Without explicit evaluation cycles, platforms may be judged primarily by activity volume rather than strategic impact.

(3) Risk of fragmentation. Without a shared understanding of each organization's role and complementarity, the Department risks becoming siloed, with separate initiatives pulling in different directions, particularly when multiple new units expand concurrently under tight space and staffing constraints.

Department-level recommendations

(1) Establish a transparent "Platform Charter & Review" mechanism for creation, evaluation, and renewal, documenting: purpose and strategic rationale; complementarity and non-duplication; governance and decision-making; evaluation metrics; and a time-bounded review schedule (e.g., midterm review and renewal review).

(2) Professionalize program management to protect faculty research time by planning administrative/URA staffing proportional to platform scale from the outset, rather than adding it after workloads become unsustainable.

(3) Integrate platform growth into a Department-level space roadmap consistent with the 2019 warning that space is a necessary condition for sustained excellence and long-term competitiveness.

(4) Where relevant, treat diversity/internationalization and language environment as measurable outcomes aligning platform-level actions (recruitment, training, and communication) with Department-wide goals.

Organization-specific evaluation

■ IPI (Institute for Physics of Intelligence; established 2018)

IPI aims to establish a research and education hub clarifying the physical principles underlying intelligence and advancing AI through mathematical physics and non-equilibrium science, with activities spanning research, education, early-career support, and international seminars/symposia.

The 2019 review explicitly described IPI as timely and recommended using it as a hub for industry-academia collaboration, while calling for broader corporate engagement and stronger public-facing communication. The committee also values IPI's strong emphasis on education, including sustained educational activities and inclusive symposium formats that encourage broad student participation alongside invited experts.

As IPI expands external engagement, the committee urges explicit protection of research time through strengthened professional program management, to avoid success-driven administrative overload.

■ TSQS (Trans-Scale Quantum Science Institute; 2020-2030)

TSQS is designed to explore the full spectrum of quantum science, build a global platform, and develop strategic plans for research training, with major overseas partners and broad internal connectivity. TSQS reports substantial research output and strong international convening activity, suggesting it has become a visible hub for the Department's quantum expansion and interdisciplinary engagement.

Given TSQS's multi-unit structure and extensive partnerships, it is particularly exposed to administrative overload. The committee recommends professional program management and clear role-sharing with other quantum-related initiatives through the proposed charter/review mechanism, and explicit integration of TSQS operational planning with the Department's space strategy.

■ QSW (Endowed Chair for Quantum Software; established 2021)

QSW targets quantum computing, information compression, and information extraction, aiming to develop quantum machine learning methods and applications, foster quantum-native talent, and return outcomes to society. QSW's structure explicitly combines research with education and social implementation, including sustained graduate-level training and continued workshops/hands-on programs supported through industry-academia co-creation. This is a tangible asset for modernizing education and talent development in compute-intensive and quantum-adjacent physics.

The committee recommends incorporating QSW's education model and outputs into Department-level planning as reusable assets (where appropriate), while ensuring that expansion of external engagement is matched by professional program management so faculty research time remains protected.

■ SQAI (Center of Innovation for Sustainable Quantum AI; 2022-2032)

SQAI is a long-term COI-NEXT program targeting Sustainable AI enabled by co-design of quantum software, HPC, and simulation technologies, organized into multiple R&D topics under an integration concept implemented on quantum-classical hybrid computing environments. The program has a co-creation model that balances open engagement with deeper joint projects, multi-site hubs, and a broad ecosystem spanning academia, local government, and industry. Its roadmap transitions from foundational development to a phase focused on proof-of-concept and implementation.

Entering the implementation-focused phase, SQAI should publish a concise evaluation framework (deliverables, software/infrastructure artifacts, reproducibility/portability, and education/talent outcomes) to make feedback loops visible. SQAI should also ensure that consortium operations are professionalized so that administrative burdens do not shift onto researchers.

■ QNSI (Quark Nuclear Science Institute; established 2024)

QNSI is an umbrella organization spanning nuclear-physics-related groups in the Department and CNS, aiming to drive innovation and strengthen international leadership, including ambitions connected to major international projects. QNSI demonstrates rapid early progress, strong institutional momentum, and strategic alignment with national-level priorities. These features align with committee-member views that CNS–Department collaboration is highly effective and that QNSI is developing into an attractive, field-leading hub.

At the same time, QNSI's own materials highlight critical bottlenecks: strengthening administrative capacity and addressing space constraints, particularly adequate workspace for faculty and staff—will be essential. QNSI should be an early test case for the Department's charter/review mechanism, including transparent governance, evaluation, and feedback into Department strategy, to ensure coherent growth rather than fragmentation.

■ RESCEU and UBI (Long-standing affiliated centers)

UBI is presented as a large cross-disciplinary platform organized into multiple research groups with advisory and steering functions, spanning multiple schools and institutes. RESCEU continues to demonstrate sustained international engagement and training activity. The committee's principal recommendation is that these affiliated centers be integrated into the Department-level charter/review logic (role clarity, complementarity, and evaluation feedback) and supported through coherent space and operational planning, rather than being treated as independent exceptions outside the platform governance framework.

INDIVIDUAL RESEARCH FIELDS

1. Nuclear Physics & Elementary Particle Physics

Nuclear Physics Theory (A0)

A0 (Nuclear Theory) constitutes a well-defined subcourse that connects the physics of QCD matter, hadron structure, nuclear structure, and neutron-star matter within a single, coherent program. The committee notes that A0's strength is not simply its breadth, but the way its complementary expertise is brought to bear on concrete, hard problems that sit at the current frontier of nuclear and QCD many-body theory.

Prof. Kenji Fukushima serves as a principal conceptual anchor in hot and dense QCD. A notable line of work addresses QCD-like gauge theories under rotation by formulating the problem in a controlled, field-theoretical setting (via imaginary rotation) and identifying a nontrivial confined regime that is accessible analytically. This program provides a clarified account of how confinement-related observables respond to rotational effects and proposes a physically transparent continuity picture that bridges perturbative high-temperature behavior with low-temperature confinement. Taken together, these results define a sustained research direction and have supported international collaboration across multiple groups.

In dense-matter astrophysics, the Fukushima group has pursued an inference strategy that is technically disciplined rather than cosmetic: low-density constraints from effective field theory, high-density behavior guided by perturbative QCD, and statistically consistent interpolation constrained by observational data are combined into a single pipeline. Within this framework, the group has emphasized diagnostics that carry real field-theory meaning, such as conformality measures based on the trace anomaly, to interpret features like the emergence of a peak in the sound speed. The committee regards this as a well-motivated approach for linking observationally inferred equations of state to underlying QCD dynamics.

Assoc. Prof. Haozhao Liang strengthens A0's low-energy axis through quantitatively controlled nuclear many-body theory and energy-density-functional development. The research themes are concrete and timely: systematic treatment of charge-symmetry breaking and neutron-skin observables, and nuclear-mass predictions at an accuracy level relevant for r-process modeling and uncertainty propagation. The committee notes in particular that this work is framed around predictive performance and uncertainty quantification, with careful attention to how model assumptions propagate into astrophysically relevant observables. In addition, Liang's program provides a natural bridge between nuclear-structure theory and the broader multi-messenger agenda, by articulating how microscopic and mesoscopic nuclear inputs affect the interpretation of observational constraints. The committee further notes that data-driven methods are positioned here as tools to improve predictive power and uncertainty quantification, and are complemented by exploratory work that tests quantum-computing methodologies on benchmark many-body models.

The assistant-professor layer contributes both continuity and renewal. Assistant Prof. Yui Hayashi (joined from YITP) is a QCD specialist who is particularly well positioned to connect field-theoretical developments in QCD with hadron physics questions, thereby strengthening A0's ability to translate fundamental QCD insights into phenomenologically relevant hadronic observables and effective descriptions. Assistant Prof. Hiroyuki Tajima adds a valuable bridge to quantum many-body physics, including cold-atom perspectives and strongly correlated techniques that are increasingly shared across nuclear subfields (e.g., pairing/superfluidity and nonperturbative many-body methods). Personnel circulation has been handled in a healthy manner: Dr. Arata Yamamoto's move from Fukushima's assistant-professor position to RIKEN is appropriately viewed as part of an effective career pipeline and continuing institutional linkage.

A0's strategic value is further amplified by active participation from RIKEN-based members, notably Dr. Takumi Doi and Dr. Masaaki Kimura, who joined the effort from RIKEN. Their involvement is substantively important: it expands the portfolio and embeds A0 in the broader Japanese nuclear-physics ecosystem, enabling joint mentoring and realistic pathways for junior researchers to develop independence while maintaining strong ties to national-scale research infrastructure. From an external-review perspective, this form of "brain circulation" is a tangible institutional asset.

Finally, A0's engagement with QNSI provides an important institutional platform for collaboration and visibility. QNSI's mission to unify quark, hadron, and nuclear physics as quantum many-body science and to strengthen UTokyo–RIKEN collaboration aligns naturally with A0's scientific scope. A0 members contribute to the intellectual core of this initiative and to its network-building activities, helping to create opportunities in which frontier theory, data analysis, and large-scale computation are brought together.

Overall, the committee's view is that A0 is a strong and steadily advancing program, with clearly articulated scientific directions, effective mentoring capacity, and a constructive mechanism for inter-institutional collaboration and renewal.

Elementary Particle Physics Theory (A1)

The elementary particle physics theory group consists of four units, two specializing in phenomenology and cosmology led by Professor Takeo Moroi and Professor Koichi Hamaguchi, who was promoted from Associate Professor in January 2026, and two specializing in the formal aspects of string theory and quantum field theory led by Professor Yutaka Matsuo and Professor Masahito Yamazaki, who joined the group in October 2024. The elementary particle physics theory group had consisted of four units for a long time and had been functioning well. The committee has positively evaluated the restoration of the fourth unit following a long vacancy that began in 2016 when Professor Yuji Tachikawa moved out. It should also be mentioned that the current four units are well balanced in research areas and are working effectively. Therefore, maintaining four units in the group is particularly important, even after the retirement of Professor Yutaka Matsuo this March.

The phenomenology group has been investigating Physics beyond the Standard Model (BSM), including the search for dark matter, a new mechanism for lepton flavor asymmetries, and the search for axions. Professor Moroi and his collaborators proposed a new method for detecting wave-like dark matter through the direct excitation of superconducting qubits. They pointed out that the quantum properties of qubits enhance signals by a factor of N^2 for N qubits. Professor Hamaguchi and his collaborators proposed a new scenario for producing large primordial lepton asymmetries based on the Affleck-Dine mechanism with Q-ball formation. This scenario is consistent with observations from Big Bang Nucleosynthesis (BBN) and the Cosmic Microwave Background (CMB), can yield the correct baryon asymmetry in both size and sign, and enhances sterile neutrino dark matter production simultaneously. Professor Hamaguchi and his collaborators also proposed an "Axion Supernova-scope" to directly detect axions emitted from nearby supernovae.

The formal theory group has been studying various symmetries in Quantum Field Theories (QFT) and related areas. Professor Matsuo worked on Quantum Toroidal Algebra (QTA) and its applications in physics. QTA is a quantum deformation of an infinite-dimensional algebra that includes the Virasoro algebra and is considered an interface among mathematics, string theory, gauge theory, and solvable systems. Assistant Professor Tatsuma Nishioka, formerly a member of Matsuo's group until his departure in December 2020, focused on black hole physics, conformal field theory, and their applications in quantum information. Assistant Professor Kantaro Ohmori, who was in Matsuo's group from May 2021 to September 2025, focused on generalized symmetries and non-invertible symmetries, which are new types of symmetries in QFT based on category theory. He played a pioneering role in finding realizations of these symmetries in four-dimensional QFT and received the Frontiers of Science Award (Physics) in 2025. Professor Yamazaki worked on the construction and classification of non-invertible symmetry-protected topological phases using duality transformation. He also studied integrable models through four-dimensional Chern-Simons theory and, along with his collaborators, clarified the mysterious relationship between the chiral Potts model and hyperbolic monopoles, originally discovered by

Atiyah in 1987. He received the Frontiers of Science Award (Mathematics) in 2025 for this contribution. In addition, he conducted research on quantum simulations. He and his collaborators advocated the bosonic sparsified SYK model as a platform to explore quantum advantage.

Although previous external reviews in 2012 and 2019 pointed out that communication between the phenomenology groups and the formal theory groups was poor, the current external review committee recognized that this situation has improved due to the efforts of group members in enhancing mutual communication: (1) The four groups are organizing a Joint Lunch meeting and an HEP Theory seminar on Mondays. (2) Assistant professors and graduate students from these groups are sharing office and salon space. (3) The phenomenology groups led by Professors Moroi and Hamaguchi are jointly organizing a weekly journal club. This positive trend should be maintained to further enhance communication among the entire elementary particle physics theory group.

Particle and Nuclear Physics Experiment (A2)

With its newly assembled faculty members, the Experimental Particle and Nuclear Physics Group is conducting world-class research and leading their respective fields.

The Experimental Particle Physics Group underwent significant personnel changes after the external review in 2021. While Professors Aihara and Asai left their positions, Associate Professor Masashi Yokoyama was promoted to professor, Associate Professor Yasuhiro Nakajima was hired, and Dr. Yorita was appointed as a professor.

Profs. Yokoyama and Nakajima are key members of the long-baseline neutrino oscillation experiments using Super-Kamiokande (SK) and its successor project, Hyper-Kamiokande (HK). They have made significant contributions to the groundbreaking finding of a hint for CP violation in the lepton sector and are leading the HK project toward confirming this finding. Prof. Nakajima serves as the Leader of T2K-SK and is also advancing detector development for HK. Furthermore, Dr. Nakajima has led observations using the Gd-loaded SK detector and achieved the significant result of showing the existence of Diffuse Supernova Neutrino Background with a significance of 2.3σ. The committee would like to highly commend the fact that an environment has been established in which Profs. Yokoyama and Nakajima are collaborating to play central roles in the large-scale HK project while vigorously promoting the development of human resources.

Prof. Yorita participates in the ATLAS experiment at the LHC, an energy-frontier particle physics experiment. He has achieved results in the precise determination of the Yukawa coupling constant of Higgs boson to top quark and tau lepton, as well as in the search for new physics. Meanwhile, he is also advancing balloon-based observations to search for dark matter through the detection of antideuterons in cosmic rays using a liquid argon TPC. The policy of simultaneously advancing small-scale experiments—which are crucial for training experimentalists—while producing results from the data analysis of the large-scale experiment appears to be effective. These two lines of research should be pursued with care, maintaining a balance and avoiding excessive burdens on staff and students.

In the Experimental Nuclear Physics field, after Prof. Sakurai's departure, the department appointed Professor Satoshi Nakamura and subsequently hired Associate Professor Suzuki, leading to the establishment of a new group for experimental nuclear physics. Prof. Nakamura is one of the leading researchers in this field, conducting experimental research on hypernuclei at Jefferson Laboratory in the United States as well as at the accelerator facility at the University of Mainz and J-PARC. He has pioneered a high-precision hypernuclear mass measurement method and determined the masses of important light hypernuclei with high precision, while also advancing high-resolution hypernuclear spectroscopy experiments using electron beams. Assoc. Prof. Suzuki has been conducting research on neutron- and proton-rich nuclei primarily at the RIKEN RI Beam Factory, while also utilizing research facilities in France and Canada. Recently, he has achieved significant results in studies of triaxial deformation and charge symmetry in nuclei.

A major milestone for this group was the establishment of the new organization, Quark Nuclear Science Institute (QNSI), in collaboration with members of the Center for Nuclear Studies (CNS) and the Nuclear Theory group within the Department. Originally, CNS consisted of two groups: one studying nuclear physics of nucleon many-body systems in collaboration with RIKEN RIBF, and another studying high-energy QCD physics using CERN LHC in Europe. By adding intermediate-energy hadron/nuclear physics such as hypernuclei, which lies between these two areas, the new institute has established a framework for comprehensive research spanning from quarks to atomic nuclei. The center also plays a role in advancing preparatory research and training personnel for the EIC project on high-energy nuclear physics, which is currently under construction in the United States and in which Japan has announced its participation. Currently, the number of staff in QNSI is increasing, which is quite favorable to the Department. Furthermore, in cooperation with Osaka University, the center is expected to serve as the core of IQPN, a nationwide network for nuclear physics research to be established in the future.

In order to ensure that organizational expansion and management tasks do not create an excessive burden, it is recommended to ask for assistance and cooperation from both within and outside the university so that the development of this organization leads to creation of outstanding research results.

Common issues for the Experimental Particle and Nuclear Physics Group are the financial and safety risks associated with sending staff and students to overseas facilities for long periods, due to the weak yen and unstable international conditions. While financial costs are primarily being covered by large-scale research grants, further efforts are needed to secure more stable, long-term funding sources. Regarding safety, it is recommended to seek assistance from specialized departments within and outside the university to establish a comprehensive risk management system.

2. Condensed Matter Physics

Condensed Matter Physics Theory (A3)

The theoretical condensed matter physics program (A3 group) consists of nine faculty members and covers a very broad and important range of topics in condensed matter theory, including strongly correlated systems, topological systems, superconducting systems, as well as cold atom gases. The A3 group also explores fundamental problems related to statistical physics and quantum information. Theoretical methods employed and developed are very diverse, ranging from standard analytical methods, numerical methods such as first principles calculation, to quantum information techniques. All the faculty members in the A3 group have achieved significant research results and have been leading the world's cutting edge research in condensed matter theory.

The first strength to be mentioned is that the Tsuneyuki group, Arita group and Todo group have been conducting highly influential research by tackling quantum many-body problems with advanced numerical methods such as first-principles calculations and numerical simulations, while their research objectives are slightly different and complementary to each other. Tsuneyuki group has clarified many novel phenomena emerging in transport properties such as thermal conductivity, dielectric properties, surface properties, etc. Arita group has an outstanding research record in theoretical design of various new materials including the prediction of high-temperature superconductivity, anomalous properties stemming from topology/quantum geometry. Todo group targets more fundamental and statistical physics oriented topics and has developed versatile numerical algorithm to attack complicated quantum many body problems. His group has also conducted high-level research related to quantum computing and machine learning.

Katsura group has extensively studied strongly correlated systems and topological materials mainly using analytical methods such as exactly solvable models, elucidating fundamental concepts underlying quantum many-body systems. Tsuji group targets strongly correlated systems with particular emphasis on their nonequilibrium properties, as exemplified by light-induced quantum phase transitions. His group has also developed new techniques to treat strong correlation in nonequilibrium conditions far from equilibrium.

Ueda group and Ashida group focus on fundamental physics from broader perspectives. Ueda group has many outstanding achievements in a wide variety of topics, keywords of which include cold atoms, nonequilibrium, information thermodynamics, machine learning, etc. In particular, his group proposed various new concepts in fundamental physics. The youngest faculty, Ashida, is a rising researcher who has an excellent research record for basic problems in the intersecting area of quantum many-body physics and quantum information/optics. These two groups play a key role in bridging condensed matter physics mentioned above and information science described just below.

In contrast to the above research groups, Murao group and Kabashima group focus on information physics/science. Murao group has high achievements in quantum information theory related to quantum computing and also problems in connection with the foundations of quantum mechanics. Kabashima group has extensively explored cutting edge topics focusing on statistical physics, information science, machine learning, error-correcting codes and cryptography, which are complementary to research conducted by Murao group.

As summarized above, all the faculty members in the A3 group are extremely active in research and play a leading role globally in their respective research fields. The committee recommends them to maintain and further enhance their research activities in the future. Since a wide range of subjects are covered, it is important to enhance the synergistic effects among different groups through intensive interactions. Especially collaborations with experimental groups are invaluable, as emphasized below in the report on the experimental groups. Although some remarkable results have been already obtained in collaboration with experimental groups, such as Arita/Nakatsuji collaboration for discovery of a magnetic Weyl semimetal Mn_3Sn and Tsuji/Shimano collaboration for observation of the Higgs mode in a superconductor, it is highly appreciated to expand such collaborative relationships among other theory/experimental groups. Finally, to maintain the high research activity, it is important to hire top-level researchers in each field in the future personnel selection.

Condensed Matter Physics Experiment (A4)

The experimental condensed matter physics program consists of seven faculty groups, covering a wide range of cutting-edge research topics. This provides the students with opportunities to learn a variety of research in the field of condensed matter physics. All the faculty members are very active in research, having outstanding publication records. They are leading scientists not only in Japan but also in the world. The impressive strong points of the A4 group can be listed as follows.

First, a wide range of cutting-edge research topics is covered, including topological surface states, non-BCS superconductivity at surfaces (Hasegawa group), spin Hall effect (Hayashi group), quantum sensing using NV-center devices (Kobayashi group), quantum transport in magnetic topological materials, antiferromagnetic spintronics (Nakatsuji group), Rashba interaction in ultra-thin films (Okamoto group), Higgs mode in superconductors, light-induced superconductivity, Floquet-engineering of topological materials (Shimano group), and bulk photovoltaic effect (Zhang group). Since the field of condensed matter physics is vast, it is important to select appropriate topics. All the above subjects have been attracting much attention in the condensed matter community.

Second, new and original experimental tools and techniques are developed in most of the groups. In order to conduct cutting-edge research, it is important to develop new experimental systems. The powerful tools are the ultrahigh vacuum (UHV) system which enables the four-probe resistance measurement under magnetic fields in UHV (Hasegawa group), hBN quantum sensors and magnetic field imaging microscope (Kobayashi group), monolayer film growth technique and STS at low temperatures (Okamoto group), low energy THz spectroscopy (Shimano group), and a cryostat with optical microscopy (Zhang group). The continuous efforts to develop new measurement techniques expand the new field of physics, and thus are highly appreciated.

The third strong point is the collaboration within the A4 group. Even if outstanding researchers are working in the same building, it is a pity if they have no interaction with each other, producing no synergy. From this point of view, the collaborative works within the A4 group, such as collaboration between Nakatsuji and Hayashi and between Shimano and Hayashi, are highly evaluated. Sharing several experimental facilities, such as a yellow clean room, works well, which is also a kind of collaboration within the group. The collaboration with the theoretical group is also active, which strengthens the quality of research.

The fourth is, as naturally expected from the groups' high activities, numerous impactful publications. Not only the number of published papers but also their quality is outstanding. It proves that the research groups in the experimental condensed matter physics of this department are at the top level in the world.

The fifth is collaboration with industry, which is still uncommon among physics departments in graduate schools of science in Japan. Owing to the discoveries of various quantum functionalities of Mn3X, Prof. Nakatsuji attracts much interest in industry. This is a good example that new findings in Physics can contribute to the technologies that enrich human life. Having the mindset that the results of basic research can be connected to the practical application is also important for the education of students.

The last strong point is the age balance of the faculty members. While one professor is retiring, a young new PI has joined. As a result, the A4 group as a whole keeps a good age distribution. If possible, it is better to employ one more new PI after the retired professor.

Compared to the strong points mentioned above, there are only a few weaknesses to consider. One issue is that the research subjects seem to be rather biased toward thin films and/or 2D materials, while only the Nakatsuji group handles bulk crystals. Since crystal growth itself is a crucial technique, this should be taken into account during the next PI recruitment process. The final comment is on the importance of collaboration with theoretical researchers. Given that there have been several successful examples, such as the joint research between Nakatsuji and Arita, it is encouraged to engage more actively in collaboration with theoretical groups both within and outside of the university. This effort would be helpful to further advance research in the A4 group.

3. Astrophysics

The Astrophysics Theory (A5) and Astrophysics Experiment (A8) groups of the University of Tokyo together form an unusually broad and well-connected program spanning the cosmic history from inflation and the dark ages to black holes, neutron stars, supernovae, and precision cosmology. A5 is especially strong in theory, computation, and astrophysical interpretation, while A8 provides complementary strength in gravitational-wave instrumentation, X-ray astronomy, and radio/CMB cosmology. A particularly impressive feature is that the two groups are not organized as isolated subfields, but as parts of a larger astrophysics ecosystem closely linked to RESCEU and to major international collaborations.

Astrophysics Theory (A5)

Within A5, Naoki Yoshida is a leading figure in computational astrophysics and early-universe structure formation. His work combines first-principles simulations, 21cm cosmology, dark-matter phenomenology, and large-scale numerical methods at a very high level. Particularly impressive are his forecasts for distinguishing cold and warm dark matter through the global 21cm signal and power spectrum, including applications to future ground-based and lunar observations.

Yasushi Suto, who retired in March 2024, has left a significant scientific legacy. To strengthen the group after his departure, Kohta Murase will join from Penn State in April 2026. His arrival will add a major high-energy astrophysics and multi-messenger component, extending the scope of A5 from neutrinos to gravitational waves, and thereby broadening the group in areas of growing international importance.

A5 has also created an outstanding research environment. The group is diverse, international, and collaborative, with affiliations extending to Kavli IPMU and RIKEN and strong ties to partners in the United States, Taiwan, Brazil, Germany, the Netherlands, France, Canada, and

Korea. Student achievements are exceptional, including Dean's Awards, President's Awards, the L'Oréal-UNESCO Prize for Young Scientists, JSR Fellows, JSPS DC Fellows, and many WINGS students. This combination of scientific excellence, international openness, and student success is a major strength.

Astrophysics Experiment (A8)

The A8 experimental group is comparably strong and broad. Masaki Ando has built and sustained a major gravitational-wave experimental program over more than a decade. His group has played an important role in KAGRA and in the broader development of gravitational-wave instrumentation, while also contributing to precision measurement and experimental gravity. This is a mature and internationally visible group with long-term impact.

Aya Bamba's X-ray astrophysics group reached a major milestone with the 2023 launch of XRISM. The group played leading roles in Galactic diffuse observations and the Xtend detector team, and has already contributed to high-profile science. Particularly notable is the discovery of clumpy ultra-fast outflows at about 0.3c from a supermassive black hole and asymmetric expansion in a supernova remnant at several thousand kilometers per second. The group is also investing in future instrumentation through the GRAMS mission and CubeSat-related detector development, while training many students.

Akito Kusaka has established an excellent observational cosmology program centered on the cosmic microwave background. The scientific goals are ambitious, including primordial gravitational waves, dark radiation, axions, sterile neutrinos, the sum of neutrino masses, and dark energy. The associated detector and optics development, especially cryogenic half-wave plates with magnetic-levitation bearings, shows that the group is both scientifically ambitious and technologically innovative.

Yuta Michimura is a particularly impressive young addition. Since establishing the Experimental Gravitational Physics Group at RESCEU in April 2024, he has already produced notable results on KAGRA mirror birefringence, vector dark-matter searches with KAGRA, improved optical-cavity searches for axion dark matter, and proposals to accelerate gravity-induced quantum entanglement. His work is ambitious and distinctive, at the interface of gravitational-wave science, precision measurement, dark matter, and quantum gravity, and it points to a promising new experimental direction.

RESCEU

RESCEU also deserves a very positive assessment. Founded in 1999, it has developed into an influential center that serves as a hub for astrophysics at the University of Tokyo. Its structure is especially effective because a relatively small core is amplified by a broader affiliate network spanning Physics, Astronomy, the Institute of Astronomy, and Earth and Planetary Science. The center is clearly international in character, with visiting researchers, international symposia, annual summer schools, outreach activities, and strong connections to major collaborations such as KAGRA, LiteBIRD, small-JASMINE, and Subaru-related surveys. The two major research pillars — evolution of the universe and cosmic structures, and gravitational-wave astrophysics and experimental gravity — provide a natural umbrella under which A5 and A8 can interact productively.

The 2020-2025 report of the RESCEU states that there are three projects, (1) Evolution of the universe and cosmic structures led by Prof. Yokoyama; (2) Gravitational-wave astrophysics and experimental gravity led by Prof. Kipp Cannon; and (3) Formation and characterization of planetary systems led by Prof. Yasushi Suto. While the report details the first two, the third is only briefly mentioned. Of course, with Prof. Suto's retirement, this project is clearly ending, it is easy to imagine that it achieved its results through skillful collaboration involving researchers in Earth and Planetary Sciences. While the results are certainly noteworthy, it would have been beneficial to also mention the results of this project. The same can be said for Professor Satoshi Yamamoto, probably in the sub-course of A8, who retired in 2023. Although he retired during this evaluation period, his research achievements, as well as his significant contributions to the astronomical community, including his position as president of the Astronomical Society of Japan, should perhaps have been mentioned in this evaluation report. Of course, these absences do not necessarily lower the overall excellent evaluation as stated below.

Overall, both A5 and A8 should be judged as highly successful and internationally competitive groups with complementary strengths and excellent future potential. The most important recommendation is to preserve and deepen the synergy between these groups, especially in multi-messenger astrophysics, dark matter, CMB and line-intensity-mapping cosmology, and gravitational-wave science. The arrival of Murase and the rapid development of Michimura’s program make this an especially good moment for continued investment in cross-group collaboration, recruitment, and student support.

4. Biophysics

Department of Physics (A7)

A series of research programs conducted by the laboratories of Profs. Chikara Furusawa, Kyogo Kawaguchi, Akinao Nose, Yasushi Okada, and Yuji Sugita aims to elucidate the universal principles governing biological systems by viewing life as a nonequilibrium physical system.

These studies span multiple hierarchical levels, ranging from biomolecular structural dynamics and intracellular state transitions to neural circuits, evolutionary processes, and information processing. A unifying feature across these diverse systems is that they can be understood within a common physical framework—namely, nonequilibrium dynamics evolving under strong constraints in a reduced effective space of degrees of freedom. Biological systems are inherently high-dimensional and complex; however, they exhibit robust and reproducible functions governed by a limited number of effective degrees of freedom. This suggests that biological phenomena should not be viewed as arbitrary high-dimensional dynamics but rather as organized dynamics constrained within structured state spaces. The central aim of this body of work is to understand the origin and nature of such constrained dynamics and dimensional reduction from the perspective of nonequilibrium physics.

A key aspect of this problem is that biological dynamics have been shaped through billions of years of evolution. In this sense, living systems are not merely nonequilibrium systems, but rather "learned nonequilibrium systems" that have been optimized through long-term processes of variation and selection. From this viewpoint, biological systems can be regarded as physical systems that embody accumulated "knowledge" or design principles refined over evolutionary timescales. Elucidating the dynamical structure and constraints of such systems represents not only a challenge for biology but also an opportunity to extend the scope of physics itself. Understanding life in this manner opens new avenues in physics by introducing systems in which history, information, and function are intrinsically embedded in dynamical laws.

Within this framework, Chikara Furusawa has demonstrated that phenotypic dynamics in evolution and cellular systems are effectively confined to low-dimensional manifolds. This finding implies that even in complex high-dimensional systems, the relevant dynamics evolve within restricted subspaces, closely related to concepts such as attractors and slow modes in nonlinear dynamical systems. Importantly, these constraints can be interpreted as outcomes of evolutionary processes acting over long timescales, thereby linking dynamical systems theory with evolutionary biology.

Meanwhile, Kyogo Kawaguchi has extended the framework of nonequilibrium statistical physics to a wide range of biological and complex systems. His work on sequence-dependent phase behavior of proteins provides a quantitative understanding of biomolecular phase separation, while studies on active matter in multicellular systems and topological defects reveal new principles of collective dynamics in living systems. Furthermore, his efforts to interpret learning processes as phase transitions suggest a deep connection between biological systems and information-processing systems, highlighting the universality of nonequilibrium phenomena.

On the experimental side, Akinao Nose investigates the relationship between neural circuit activity and behavior using model organisms such as *Drosophila*. His work demonstrates how coordinated behavior can emerge from relatively small neural circuits, providing concrete examples of how efficient information processing and structured dynamics arise in systems with limited degrees of freedom. These findings offer important insights into the physical principles underlying biological information processing.

A particularly critical role in this research landscape is played by the imaging technologies developed by Yasushi Okada. By achieving high temporal resolution, long-term observation, and low invasiveness simultaneously, these technologies enable continuous tracking of intracellular states and transitions over extended timescales. Such measurements allow direct experimental access to trajectories and transition probabilities in state space, providing a foundation for describing living systems as stochastic processes. Notably, the ability to capture rare events and slow dynamics represents a significant advance, opening new possibilities for experimentally testing theories in nonequilibrium statistical physics.

Complementing these approaches, Yuji Sugita develops and applies advanced molecular dynamics simulations and enhanced sampling techniques to reconstruct free-energy landscapes and transition dynamics of biomolecules with high accuracy. This work bridges microscopic molecular interactions and macroscopic functional dynamics, providing essential insights into how complex biological functions emerge from underlying physical interactions.

The significance of conducting such research within a physics department is profound. By treating biological systems as "learned nonequilibrium systems," this research challenges and expands the traditional boundaries of physics. It introduces systems in which long-term historical processes, information encoding, and functional optimization are integral components of dynamical behavior. As such, it calls for the development of new theoretical frameworks capable of describing systems with embedded memory and evolutionary constraints.

Moreover, the impact of this research extends beyond biological physics to other areas of physics. The study of free-energy landscapes and transition dynamics in biological systems may offer new perspectives on glassy systems and complex energy landscapes. The concepts of dimensional reduction and constrained dynamics are also highly relevant to high-dimensional data analysis and machine learning, suggesting potential contributions to the growing interface between physics and information science.

In addition to its research significance, this body of work has substantial educational value. Introducing biological systems into physics education enables students to engage with complex nonequilibrium systems where theoretical concepts such as free-energy landscapes, stochastic processes, and dynamical systems become directly observable and tangible. This enhances the intuitive understanding of abstract physical principles and demonstrates their applicability to real-world systems.

Furthermore, viewing biological systems as evolutionarily “learned” systems encourages students to think beyond static laws and consider the interplay between dynamics, function, and information. The integration of experimental, theoretical, and computational approaches in this research also reflects the modern style of physics, providing students with a comprehensive perspective and a versatile skill set applicable to a wide range of scientific challenges.

In summary, these research programs collectively aim to understand biological systems as nonequilibrium dynamical systems shaped by evolution, thereby uncovering universal physical principles underlying life. By addressing systems that embody billions of years of accumulated “knowledge,” this work not only advances our understanding of biology but also opens new directions for physics itself. It is expected that continued development and conceptual integration of these studies will have a profound impact on both the future of physics and interdisciplinary science.

Universal Biology Institute (UBI)

The Universal Biology Institute (UBI) aims to address the fundamental question, *“What is life?”*, by integrating diverse research approaches including theory, measurement, synthesis, and information analysis. Its research philosophy—seeking to understand living systems not merely as collections of molecular mechanisms but as phenomena governed by universal principles such as evolution, self-organization, information processing, and nonequilibrium dynamics—has the potential to expand the traditional framework of life sciences. The integrated research structure combining theoretical studies, experimental investigations, advanced measurement technologies, and synthetic approaches represents an important attempt to explore general principles underlying living systems. In particular, the attempt to address the fundamental distinction between living and non-living systems through both theoretical analysis and synthetic reconstruction of biological functions is noteworthy. If life-like properties such as self-replication and evolution can be reconstructed from non-living molecular systems, this would provide important insight into the conditions necessary for the emergence of life and the possible universal principles underlying living systems. The integration of theory, experiment, and synthetic reconstruction therefore represents a promising direction toward understanding both the origin of life and the general principles of biological organization. At the same time, living systems are extraordinarily sophisticated, yet they are also the product of long evolutionary histories and therefore contain considerable redundancy, contingency, and historical complexity. For this reason, it remains an open question whether the accumulation of knowledge about individual physical processes—such as nonequilibrium dynamics, phase separation, or biological information processing—will directly lead to the discovery of universal principles of life. It is therefore important to clarify whether life can ultimately be understood within the conceptual frameworks of existing physics and information science, or whether fundamentally new theoretical concepts beyond these existing paradigms will be required. Addressing this conceptual question is itself an essential part of tackling the broader question of what life is.

Furthermore, the research activities of UBI are inherently interdisciplinary. However, interdisciplinary research cannot be achieved simply by bringing together researchers from different fields within a single organization. Meaningful interaction between researchers in physics, biology, information science, chemistry, and related disciplines must be actively fostered so that new research questions can emerge collaboratively. To achieve this, it will be important to establish institutional mechanisms that facilitate organic interdisciplinary collaboration, including shared research spaces, organizational structures that promote cross-disciplinary research planning, and flexible operational funding that supports exploratory collaborative projects. Such institutional foundations will be essential for enabling the truly integrated research environment required for the advancement of universal biology.

Overall, UBI represents an ambitious research initiative that seeks to provide new perspectives on one of the most fundamental questions in science. The question *"What is life?"* extends far beyond the boundaries of biology itself and lies at the center of multiple academic disciplines, including physics, information science, and philosophy. UBI is therefore expected to pursue this challenge with a scale and ambition worthy of positioning it as a central intellectual mission of the University of Tokyo.

If there is to be a research institute that directly confronts this question, UBI is well positioned to take on that role.

5. General Physics (A6)

This A6 subcourse is interdisciplinary and incubatory, creating new branches of subcourses like A7(biophysics) and A8(astrophysics and astronomy) in the past. In fact, there have been important changes in "General Physics" since 2012, in that the Department strengthened biophysics as one of the major branches, while "ultracold gases and information thermodynamics" and "quantum information" were transferred to the "Condensed Matter Physics" program.

Following the note in 2019 by the External Evaluation Committee that the Department should consider next candidates to succeed the tradition and pursue further development in Atomic, Molecular, and Optical (AMO) physics, the Department has successfully hired Dr. K. Aikawa as a new faculty member in 2024. Considering the impressive research achievements, it would be a good idea to promote the young faculty members in this subcourse to full professors.

AMO physics

Prof. Kiyotaka Aikawa studies levitated nanoparticles which are a new quantum system that is expected to provide an opportunity to investigate the transition from classical physics to quantum physics. He has developed an apparatus for trapping and cooling a nanoparticle in an optical lattice, demonstrating an efficient feedback-cooling approach based on damping via electric fields.

He suggested that this approach can potentially reach the quantum ground state and beyond. Subsequently, he realized feedback cooling of the motion of a neutral nanoparticle to the quantum ground state, by investigating the velocity distribution of a nanoparticle in the ground state. He especially realized feedback cooling on all the angular motions. With this process, the velocity distribution of the center-of-mass motion near the ground state recovers the expected width in agreement with the phonon occupation number.

The most recent achievement is the realization of quantum squeezing of a single neutral nanoparticle trapped in an optical lattice, which is the first for a nanoparticle. The velocity measurement of a nanoparticle released from an optical lattice, after the squeezing via sudden change of the trapping potential, reveals the narrow velocity variance below the standard quantum limit expected for the ground motional state. This is a breakthrough in the levitated nanoparticle study.

Plasma Physics

Prof. Akira Ejiri’s research topic is the high-temperature, high-density plasma for nuclear fusion energy to overcome the Coulomb repulsion. More specifically, he studies thermonuclear fusion in a tokamak configuration, a promising candidate for generating abundant, safe, and clean power, as well as plasma physics characterized by highly nonlinear and far-from-equilibrium state. He studies a complex system of various particles including electrons, ions, atoms, molecules, and solids, as well as magnetic and electric fields, ranging from microscopic scale of about 10 micron and 10 ps to macroscopic scale of 10 m and 1000 s.

He performs basic tokamak plasma physics studies on the TST-2 device located at the University of Tokyo, developing various unique antennas and so on, in addition to the collaboration with JT-60SA at QST, LHD at NIFS, LATE at Kyoto University, and QUEST at Kyushu University. His research includes plasma diagnostics to reveal new physics, helpful for future power plants operating under harsh conditions. He also contributed to the establishment (2024) of FAST project aiming at the testing of fusion energy systems as a joint project of private startup companies and researchers.

Experimental Statistical Physics

Prof. Kazumasa Takeuchi has been a world-leading figure in the field of experimental statistical physics. His research highlights since the year 2019 are given below.

(1) Study of Kardar-Parisi-Zhang (KPZ) universality class, central in the context of universal scaling laws for systems driven out of equilibrium, from liquid crystal to integrable spins, especially the first direct observation of the stationary state of the KPZ class (Iwatsuka et al., PRL 2020), and resolving the mystery around circular interfaces (Fukai and Takeuchi, PRL 2020), and finding the KPZ signatures in spatiotemporal chaos (Fukai and Takeuchi, Chaos 2021). Most recently, Takeuchi combined spin simulations and his knowledge of exact solutions and found evidence that KPZ somehow rules integrable spin chains only partially (Takeuchi et al., PRL 2025), opening a new research direction in the field.

(2) Development of a new membrane-based microfluidic device for dense bacterial populations (Shimaya et al., Commun. Phys. 2021), leading to various new findings including scale-invariant cell size fluctuations (Shimaya et al., Commun. Phys. 2021), smectic order formation of starving bacteria (Shimaya et al., Soft Matter 2025), and a bacterial glass transition.

(3) Discovery of a glass transition for bacteria confined in a closed space (Lama et al., PNAS Nexus 2024), revealing the similarity and difference from thermal glass transitions. This caused a sensation in the community of glass physics.

(4) Study of 3D topological defects of passive and active liquid crystals in both molecular liquid crystals and bacterial populations, including the first direct observation of 3D defect dynamics in liquid crystal (Zushi and Takeuchi, PNAS 2022; Zushi et al. Phys. Rev. Res. 2024), and 3D effects of defects promoting vertical growth of bacterial colonies (Shimaya and Takeuchi, PNAS Nexus 2022).

(5) Expansion of the field, including the discovery of rigidity transition of extremely deformable particles (Poincloux and Takeuchi, PNAS 2024), route to bacterial turbulence (Nishiguchi et al., PNAS 2025), experiments on Ising dynamical scaling laws (Almeida and Takeuchi, PRE 2021), active colloids with bipolar motility (Kato et al., Soft Matter 2022), etc.