The Power of FoPM
Discover the strength and diversity of FoPM

Proactive & Diverse
Global communication and respect for diversity

Across Disciplines
Broaden your research horizons

Beyond Borders
Realize the dream of doing global research

AI & Quantum Computing
Common knowledge for the next generation

The University of Tokyo

FoPM

Forefront Physics and Mathematics Program to Drive Transformation

The Power of FoPM

Discover the diversity and strength of FoPM

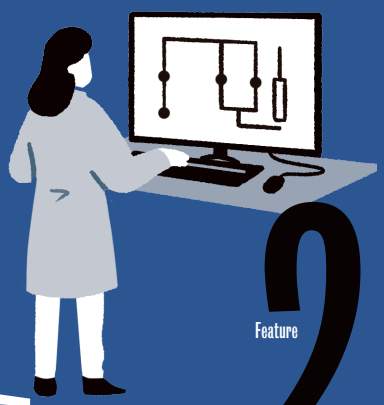
FoPM started out with the aim of training scientists to develop a broad perspective and the ability to make an impact in fields outside their area of expertise. That's why it offers such a diverse and powerful curriculum.

Integrated Master's–Doctoral program with financial support

Feature 1

FoPM is an integrated Master's–Doctoral program that trains "knowledge professionals," those with the ability to discover and apply new knowledge. In the hope that students will have the peace of mind to devote themselves to their research and studies during the 5 years of the program, FoPM provides financial support to both Master's and Doctoral students. Students set their own research goals and evaluate their own progress using the academic portfolio system. They are assessed in the Qualifying Examination (QE), which determines whether students may remain in the program as Doctoral students, and the Final Examination (FE), which marks their completion of the program.

AI and quantum computing as vital science skills



Feature 2

Reflecting the idea that AI and quantum computing are not only essential for cutting-edge science, but also a vital skillset for those who will lead the future of our planet, students are required to take courses in one or both of these subjects. In the Quantum Computing course, students have access to a state-of-the-art IBM Quantum computer and get hands-on experience in its use. The AI course gives students an overview of the basics of machine learning, data analysis, data mining, and other fundamental aspects of the field.

Multiple encounters with other disciplines

The monthly 4PM Seminar is a place where FoPM students can interact freely beyond the boundaries of their laboratories. Each month, a diverse range of invited speakers give lectures on their research, and students give and evaluate each other's short presentations aimed at those working in other fields. In the Lab Rotation, students spend time in a second research group, which gives them the opportunity to acquire a broad perspective beyond their discipline. They also gain new perspectives through insights from their secondary supervisor, who specializes in a different area of research to the student.

Feature 3

Feature 4

Research experience beyond national borders

FoPM provides students with the chance to experience academic research or a corporate internship overseas. Students are required to take part in this International Research Experience between the 2nd year of the Master's program and the 2nd year of the Doctoral program to increase their competitiveness on the world stage.

Feature 5

Science communication skills to promote research to the world

In the mandatory hands-on Academic Writing and Presentation course, students learn how to give effective presentations, how to write high-impact papers and submit them to major scientific journals, and about the latest trends in academic publishing. There is a separate course for mathematics students that focuses on the specific skills needed in this discipline.

Feature 6

Truly global leadership through Diversity and Ethics Training

FoPM's Diversity and Ethics Training aims to equip students with truly global values. It covers unconscious biases related to gender, sexual orientation, race, and more, as well as ways to overcome such biases and contribute to an inclusive society.

Enthusiasm to solve social issues with an entrepreneurial mindset

Feature 7

The Mathematics and Physics Entrepreneurship course supports students who want to make use of their expertise in basic science to take on the challenge of starting their own company. Guest entrepreneurs act as lecturers and students systematically learn how to set up a business from the very beginning. FoPM also actively promotes practical research with industry. The Frontiers of Mathematical Sciences and Society course shows students how mathematics can be used in industry and other disciplines, while the Mathematics in Society Hands-on Course gives students the chance to go beyond the conventional applications of mathematics and apply their skills to solve problems presented by industry. Classes such as the SDGs Course and the Executive Program help students to gain an understanding of the issues faced by society today. This gives them the broad awareness needed to appreciate how their specialist knowledge of physics and mathematics can be applied to the benefit of the world.

Feature 8

Practical know-how for a future global career

The International Career Seminar encourages students to think and learn about their future careers from a variety of perspectives. PhD graduates active in various sectors, both in Japan and overseas, are invited to each seminar as role models. They talk about their individual experiences, their thought processes as students, and why they chose their current career.

Proactive & Diverse

The Power of FoPM 01

Develop global communication skills and respect for diversity

FoPM provides students with the skills they need to become the "knowledge professionals" of the future. Knowledge professionals can communicate with the world beyond their field of expertise, and possess a broad perspective cultivated through experience of a diverse environment.

The program's mandatory Diversity and Ethics Training highlights the importance of respect for minority groups and a balanced awareness of gender. Students learn that respectful interaction with people of different genders and backgrounds brings new perspectives that will help them to become researchers with true global sensitivity and values.

In the Academic Writing and Presentation course, students learn the skills needed to write scientific papers and give effective presentations in English. The program also offers courses to bring students in touch with social issues and innovation, including support for those aiming to start their own business.

Keywords

1. Diversity and Ethics Training
2. Empowerment of female students
3. Academic Writing and Presentation
4. Social innovation

1. FoPM's Diversity and Ethics Training develops students' abilities to interact with people with different viewpoints and provides a new approach to analyze opinions. Students also learn how to protect the rights of minority groups and make use of different perspectives.

2. FoPM operates a mentoring system in which each student is assigned a secondary supervisor. This gives students a place to discuss any problems they may be having and provides particular encouragement to female and minority students.

3. In the Academic Writing and Presentation course, students learn about writing and publishing scientific papers in English and how to give presentations that will leave a lasting impression on their audience.

4. FoPM offers a variety of courses to encourage students to engage with societal issues and social innovation. These include courses that support students aiming to start their own business, those in which students address real-life issues raised by industry, and courses on the UN's Sustainable Development Goals (SDGs).

Turn the page for a discussion with FoPM students →

FoPM offers global opportunities and the joy of research

Diversity and Ethics Training, Academic Writing and Presentation, International Symposiums, 4PM Seminars, International Career Seminars. FoPM offers all this and more. The program's unique features and curriculum provide students with a diverse range of opportunities and support. We ask five program students for their frank opinions on the benefits and appeal of FoPM.

International Research Experience broadens students' horizons

——What do you like the most about FoPM?

Yoshii: I was excited to see the program included the International Research Experience. My field is quasi-periodic systems, but there are not many theoreticians in Japan nowadays, and the flow of knowledge to the younger generation has stalled. In Europe, however, it is more common to do research based on individual interest rather than following trends. Thus, many people continue to build on the knowledge of the past. Spending 3 months and having discussions in such an environment in France was extremely valuable.

Morii: I spent 4 months in the US during the winter of my first year as a Doctoral student. I visited the research institute of one of my collaborators, whom I met face-to-face for the first time after being in contact online for a long time. The experience of living abroad and conducting research in an English-speaking environment gave me the chance to think realistically about what it would be like to be a researcher at an overseas research institute in the future. My English skills also greatly improved during the 4 months. I did not think doing research in a different environment would be so stimulating.

Naokawa: I will go abroad in spring this year (2025). First, I will spend 2 months in Munich (Germany) and then a month in Cambridge (UK), with stops in the Netherlands and Manchester (UK) in between. I will work on my current research topic, cosmic birefringence, a phenomenon related to photons in the early universe with a deep connection to unknown elementary particles and dark energy. In the UK, I will do research using observational data of photons in the early universe. In Germany, I am planning to do research using a different kind of photons for a newly developed method. I am very much looking forward to it.

Yaman: I am thinking of doing my International Research Experience around fall this year so that it fits in with my current research schedule.

Aoyama: I am in a similar situation and plan to go sometime this year. I want to focus on my research until then and look for a place that allows me to make the best use of my results.

Secondary supervisors and Lab Rotation

Naokawa: I find the secondary supervisor system extremely useful. My supervisor is an expert in theoretical cosmology. While I study under him, I also have a secondary supervisor who is an expert in observational astronomy in the visible light range. I had the chance to operate a large telescope, which was a fun learning experience. My case is unusual as my secondary supervisor switched jobs, and so I got a new secondary supervisor specializing in radio astronomy. As a result, I have had two secondary supervisors, with expertise in optical and radio wave astronomy, in addition to my supervisor in theoretical physics. My current secondary supervisor has helped

First-year Doctoral student, Department of Mathematical Sciences

Temma Aoyama

I am enrolled in the mathematics Doctoral program. I study symmetries in mathematics, more specifically, the representation theory of Lie groups.

Third-year Doctoral student, Department of Astronomy

Kaho Morii

I usually do research at the National Astronomical Observatory of Japan. I analyze radio telescope data of the environment of newly forming massive stars.

Second-year Doctoral student, Department of Physics

Fumihiro Naokawa

I study cosmology, how the universe was formed and why it is in the state it is in. Thanks to my experience at an observational astronomy lab, I do both theoretical and observational research.

As a FoPM student, I get to hear the views and values of people in other fields.

Temma Aoyama

I gained so much from my long-term research visit in the US.

Kaho Morii

I am doing both theoretical and observational research thanks to the secondary supervisor system.

Fumihiro Naokawa

me tremendously as I have been trying to apply radio astronomy data to the theoretical cosmology research I am doing under my supervisor. I am also continuing my astrophysics research using optical observations, which I owe to my first secondary supervisor.

Yaman: I find the secondary supervisor system valuable as well. My field is experimental astrophysics and I worked on a research project with my secondary supervisor for a month during the Lab Rotation. He spends most of his time in Kamioka in Gifu Prefecture, but we meet and talk about various topics whenever he is in Tokyo. I am grateful that he can give me career advice, too.

Raising awareness with Diversity and Ethics Training

——How did you find the Academic Writing and Presentation course? I heard even Michael Jackson was mentioned in class (laughs).

Morii: My first impression was that it was rather different from my other classes. It is indeed a unique and quirky course (laughs).

Aoyama: The course was useful for learning the basics of academic writing because when you actually come to write a paper you usually just have to jump right in.

——What did you think of the Diversity and Ethics Training?

Aoyama: It was a shocking experience for me. The lecturer came from a physics background but is now doing research in the field of Science, Technology and Society. Above all, I thought the content was fascinating from a social science perspective. The lectures were very logical and precise and she presented contemporary social issues based on facts revealed by scientific inquiry. I found it very persuasive and insightful.

Yaman: What left the strongest impression on me was the importance of first becoming aware of the prejudices we may have. In the class, I took a prejudice test, which made me realize that I, too, have unconscious biases.

Yoshii: The lecturer presented many specific examples, such as the fact that even though there are few women in science in Japan, that is not the case overseas. I became aware that even my "common sense" is biased, something to be conscious of when going abroad or interacting with other people.

Financial support allows students to focus on research

——What do you think about FoPM's financial support system?

Naokawa: I am incredibly grateful. I am sure there are many people who give up on going to graduate school for financial reasons, so support like this goes a long way. I hope more programs follow suit.

Morii: I have been able to concentrate on my research since I received support starting in the Master's program. Hearing from my seniors that they had to work part-time while doing research in graduate school made me realize how fortunate I was not to have to do the same.

Yaman: After my undergraduate studies, I was not sure whether I would go on to graduate school and get a job with a Master's degree or go on to the Doctoral program. When I learned that FoPM provided financial support for the Doctoral program, I knew I could continue my studies with peace of mind.

Aoyama: I was in a similar situation. It was the financial support that allowed me to continue my studies after my Master's. I had the impression that graduate students worked part-time as well as doing research, and I worried whether I would be able to keep up. The financial support from FoPM erased those fears.

Yoshii: Actually, I saved up some money by working part-time as a private tutor during my undergraduate years because I knew I wanted to go to graduate school. But thanks to FoPM's financial support, I could do so without using my savings (laughs).

Third-year Doctoral student, Department of Applied Physics

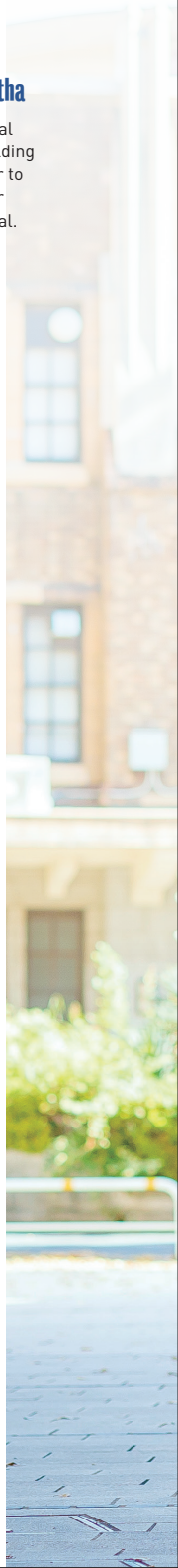
Mao Yoshii

I study condensed matter physics, specifically how two-dimensional materials, materials first created this century in which atoms bond to form a two-dimensional shape, interact with each other, and how their interactions could be exploited. Recently, I have been focusing on superconductivity phenomena.

First-year Doctoral student, Department of Physics

Yaman Singh Shrestha

My field is experimental astrophysics. I am building a dark matter detector to search for dark matter axions. I am from Nepal.



Getting to talk to world-leading experts at the FoPM International Symposium left a strong impression on me.

Mao Yoshii

I have learned how to thrive in academia at the International Career Seminars.

Yaman Singh Shrestha

——You gave poster and oral presentations at the FoPM International Symposium. How was the experience?

Yoshii: It was a real pleasure to have world-class researchers whom we would otherwise rarely meet come to the symposium and to get to talk with them casually over dinner.

Aoyama: A fellow FoPM student in the Department of Mathematical Sciences heard my presentation and became interested in it, which led us to form a study group. I am very grateful for that.

Morii: Usually, academic conferences are gatherings of experts in the same research field——in my case, astronomy. However, the FoPM International Symposium had a completely different, creative atmosphere, where we could go to talks by well-known researchers and connect with other FoPM students from different fields. It was also a great opportunity to talk directly with the speakers after their short talks and poster presentations.

International Career Seminars for a flexible future

——Have the International Career Seminars been useful?

Naokawa: The producer of the NHK program "Cosmic Front," which I have loved since I was a kid, was a guest at the first seminar I attended. I was ecstatic that I got to talk to him directly.

Yoshii: I also participated in the same seminar. Until then, my career ideas were rigid, and I thought I would follow in the footsteps of my seniors, going into manufacturing or finance. Hearing about scientific advisor jobs at NHK and other opportunities where I did not know I could leverage my Doctoral degree has broadened both my options and horizons.

Yaman: I have not yet decided whether to join the private sector or stay in academia after I graduate, but it has been great to hear from those in academia. I have learned a lot about what kind of work life I can expect and what kind of challenges I might face if I stay.

Morii: Many of the invited speakers, both at the International Career Seminars and the 4PM Seminars, have had unconventional career paths. For example, some are now doing research in a different field to that in which they received their Doctorate; others are working for companies in areas unrelated to their field of expertise. I have learned to think flexibly, and when the time comes for me to make a change, I feel I will have the confidence to change my research field or go down a completely new path.

Aoyama: I am sorry for the unrelated comment (laughs), but I really enjoy going out to dinner with everyone after the seminars and making friends with people I have never talked to before.

——You all seem very lively. Are you enjoying your research?

Naokawa: I sometimes feel research is physically draining, but in the end, it is fun and fascinating.

Yoshii: I usually enjoy it, too. It is tough when things are not going well before I have a paper to submit, but even at times like that, hearing everyone's funny stories at the 4PM Seminars cheers me up (laughs).

——Thank you for your time! I wish you success in your research.

Diversity & Inclusion

Diversity and Ethics Training

Respect for human diversity is essential in research

FoPM places a strong emphasis on the value of human diversity. Be it gender, nationality, or something else, we all have unconscious biases and preconceptions about people with a different physical or cultural background to our own. FoPM believes that tackling such biases, accepting human diversity, and interacting respectfully with all people are essential for the advancement of research. This is why FoPM's Diversity and Ethics Training is a mandatory part of the curriculum.

Through lectures given by an expert in diversity education, the Diversity and Ethics Training opens students' eyes to the biases they have unconsciously developed towards people of different genders and cultures. They learn how to overcome these biases and contribute to an inclusive society. Ultimately, FoPM aims to create an environment in which students of all genders are accepted equally and, as a result, to maximize the potential of researchers from all backgrounds.

At the same time, the seminar provides an opportunity for students to learn about and discuss their ethical obligations as scientists, as well as their responsibilities towards society and the global environment.

Prof. Hiromi Yokoyama of Kavli IPMU has been giving this seminar since the start. Her lively lectures, which also touch on contemporary topics such as genomics and AI, are well received by FoPM students.

Left: Diversity and Ethics Training materials. Right: Prof. Hiromi Yokoyama (left) and Prof. Hitoshi Murayama (right) at the seminar.

Alumni Q&A #1

Messages from FoPM Alumni

FoPM's International Research Experience brought me to UC Berkeley

Q: What is your strongest memory of FoPM?
A: The FoPM Symposium. Events had mostly been held online during the pandemic and I was feeling a little lonely. I found it stimulating to catch up with other students and discuss research in person after such a long time.

Q: What has been useful for your career?
A: The International Career Seminar gave me the chance to hear from people working in a variety of industries, not just in academia. This provided a good stimulus when I had to choose what I was going to do after I graduated.

Q: How was the interdisciplinary exchange?
A: I realized that, even if we think we understand each other at first, there can sometimes be misunderstandings between researchers in different disciplines because common knowledge and thought processes differ between fields. When I later collaborated with researchers in chemistry, this helped me avoid becoming too fixated on the ideas we take for granted in my own field.

Q: What about the International Research Experience?
A: I visited the University of Minnesota and UC Berkeley, where I worked on the assembly of the FOXSI solar sounding rocket experiment, which was later successfully launched. I also joined discussions on another satellite project, which led to me becoming a researcher at UC Berkeley.

Department of Physics
Shunsaku Nagasawa
Current affiliation: Space Sciences Laboratory, University of California, Berkeley

Across Disciplines

The Power of FoPM 02

Broaden your research horizons through cross-disciplinary exchange

FoPM fosters creative intelligence by promoting cross-disciplinary exchange. By interacting with, learning from, and doing research with students and researchers from different disciplines, students uncover new perspectives and values that enrich and deepen their research.

FoPM's Lab Rotation, secondary supervisor system, and 4PM Seminars provide students with the chance to do just this. All students spend time in a second research group during the Lab Rotation. They are assigned a secondary supervisor, also from a different discipline, with whom they regularly discuss their research. The 4PM Seminar features research presentations from acclaimed researchers from around the world and serves as a forum for cross-disciplinary exchange.

Researchers must continually reassess their goals and reconsider their path towards them. FoPM's cross-disciplinary exchange activities help students cultivate the broad perspective that they need to do this.

Keywords

1. Lab Rotation
2. Secondary supervisor system
3. 4PM Seminar

1. FoPM students are required to conduct research in a laboratory other than their own, which gives them the opportunity to acquire a broad perspective before specializing in a particular field.

2. Students select a faculty member from a different discipline to act as their secondary supervisor. Regular discussions with an expert from outside their field of expertise allow them to broaden their research horizons.

3. The 4PM Seminar is held once a month on Wednesdays at 4 pm and features invited lectures and student research presentations. FoPM students must present their research at least once during their time in the program. After the seminar, there is the chance for informal discussion among the invited speakers, faculty members, and students.

Turn the page for interviews with FoPM students

Another world: Students stringing together mathematical formulas on a large blackboard

To make the most of the Lab Rotation, I chose a research group in math because I wanted to get a glimpse into a field different from my own, experimental physics. I chose a lab led by a woman to overcome my bias of scientific researchers being men. I had already taken FoPM's Diversity and Ethics Training, and rather than just understanding the subject intellectually, I wanted to make the unprejudiced view my default.

It was a month-long program. Each week, I spent several hours having discussions with my secondary supervisor. Then, on the weekends, I continued working on problems on my own. My research topic was related to Yang–Baxter maps, a class function closely related to integrable systems in physics. By choosing this topic, my primary aim was to learn how to solve complicated equations quickly using mathematical tools. Although it was a short period, I was able to produce results that led to the publication of a paper, and this gave me confidence. Moreover, the experience was useful for my main research topic as well.

The lab I joined actively collaborates with both domestic and international researchers. So, after returning to my own lab, I also began to proactively interact with more people.

One seminar given by a student from the lab I joined for the Lab Rotation left a lasting impression on me. Seeing the student incessantly write mathematical formulas on the large blackboard felt like experiencing a completely new world.

I wanted to get a glimpse into a field different from my own and overcome my bias that 'science researchers are men.'

I chose to do my Lab Rotation in a mathematics group run by a woman and experienced a good kind of culture shock.

Second-year Doctoral student, Department of Applied Physics

Ryosuke Uozumi

Research field: Laser spectroscopy. Lab Rotation with Prof. Makiko Sasada, Department of Mathematical Sciences, Graduate School of Mathematical Sciences.

Across disciplines: My experience

Second-year Doctoral student, Department of Physics

Yuto Fukushima

I could not understand a word at the seminar on the first day

During my Lab Rotation, I participated in a lab seminar about special relativity at the Institute for Cosmic Ray Research. I can usually put my hands to work assembling devices and conducting experiments, so I felt shocked on the first day when I could not understand a word of what was being said. It made me realize the value of having experiences in different fields. I had a tough time solving the formulas, but as I progressed, they kept revealing surprises about the physics of the universe. Learning about relativity allowed me to appreciate anew the wonders of space and quantum phenomena.

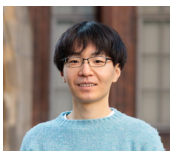
Across disciplines: My experience

First-year Doctoral student, Department of Physics

Keisuke Murota

Learning how to absorb knowledge from another field will be helpful in the workforce

For my Lab Rotation, I joined a probability and statistics research group at the Graduate School of Mathematical Sciences. I read papers with my secondary supervisor to complement my field of expertise, computational physics, from a mathematical point of view. Gaining a deeper mathematical understanding of modeling time series data using point processes was particularly valuable. I believe this program helps students develop multifaceted thinking skills and the ability to absorb knowledge outside their field of expertise, which will be helpful even after entering the workforce.



Across disciplines: My experience

Second-year Master's student, Department of Physics

Chikara Kawai

I had a unique experience in my Lab Rotation at Super-Kamiokande

I was assigned to Prof. Shigetaka Moriyama's laboratory in the Institute for Cosmic Ray Research for my Lab Rotation and participated in the second gadolinium (Gd) loading to the tanks of Super-Kamiokande at Kamioka Observatory. Measuring the Gd concentration in the tanks and the neutron capture time constant of the Am/Be calibration source gave me a unique experience upgrading and evaluating detectors used in experimental particle physics. I believe this exposure to a different field will help my future research.

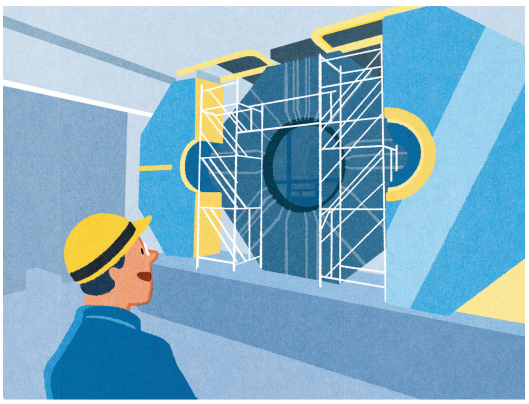
Exploring new physics by participating in KEK's Belle II experiment

Under the guidance of my secondary supervisor, I got to go to the High Energy Accelerator Research Organization (KEK) to participate directly in the Belle II experiment, which explores new avenues beyond the Standard Model of particle physics. My area of expertise is in radio astronomy, developing direct detectors, but there are similarities in terms of detecting flying particles. I got the chance to be involved in the performance evaluation of scintillators used as triggers. Learning firsthand how performance is evaluated and how research is conducted in a different field was very rewarding. The validity of our performance evaluation had to be demonstrated rigorously, so I struggled with the appropriate interpretation. However, I am now capitalizing on this experience in my own research.

The Lab Rotation allowed me to broaden my perspective by experiencing a different field early in my studies. I have always tried to be meticulous when processing data from experiments. But after seeing the standards that particle physicists hold themselves to, my standards have gotten even higher.

Prof. Higuchi, my secondary supervisor and a particle physicist, provides helpful advice based on his experience. There are many things I would not have noticed without his suggestions. Thanks to this system, I receive feedback from a perspective different from that which I get in my own lab. It has helped me rethink how to proceed with large-scale research.

I work on the development of direct detectors for radio astronomy and was hoping to get hands-on experience during my Lab Rotation.



I got to go to KEK with my secondary supervisor and participate in the Belle II experiment.

First-year Doctoral student,
Department of Astronomy

Shuhei Inoue

Research field: Radio astronomy. Secondary supervisor: Prof Takeo Higuchi, Kavli IPMU. Lab Rotation at the High Energy Accelerator Research Organization (KEK).

Across disciplines: My experience

First-year Master's student,
Department of Physics

Risako Tagami

Meetings with my secondary supervisor are a valuable source of new ideas

During my Lab Rotation, I got a glimpse into cosmology, a way of understanding the universe from a different perspective. Being exposed to the atmosphere and culture of a different laboratory has given me inspiration and a valuable opportunity to objectively review my research methods. In particular, the meetings with my secondary supervisor have deepened my understanding and helped me come up with new ideas. I not only get the chance to talk one-on-one with a professional researcher but also get asked questions that I would not get from someone in my own field.

4PM Seminar

Once a month on Wednesdays at 4 pm, a forum for creative exchange that even Nobel Laureates have joined

The 4PM Seminar, a play on words on the name of the program, is a monthly creative exchange forum held on Wednesday afternoons at 4 pm. Its purpose is to provide a platform where students can interact with acclaimed researchers and engage in broad-ranging discussions with each other. Each seminar starts with a lecture given by an invited speaker. Past speakers have included Fields Medalist Andrei Okounkov and May-Britt Moser, Nobel Laureate in Physiology or Medicine. After the lecture, students give short presentations to their peers, with the aim of improving their skills in explaining their research

to those working in other fields. Then there is time for informal discussion, where students can talk with people they would otherwise not have the chance to meet. The seminar is a great opportunity for FoPM students to exchange ideas and improve their communication skills.

Career Diversity

International Career Seminar

A space to consider future careers from multiple perspectives

FoPM's International Career Seminar is a space for students to interact with guest speakers active in a broad range of sectors, both in Japan and overseas. The chance to meet a variety of role models encourages students to think and learn about their future careers from multiple perspectives.

Speakers invited to the International Career Seminar hold Doctoral degrees and are suitable role models for FoPM students. They include not only those working at the forefront of industry, government, academia, and research, but also those following their own unique paths. For example, science PhD holders working in the media and as a Buddhist monk have also given talks.

One seminar focused on the path to working as a postdoc overseas. In this seminar, researchers who had worked at institutions such as UC Berkeley or CERN talked about their experiences. At the same time, students were given advice on how to write effective applications for postdoctoral positions. FoPM will continue to provide guidance on this and other focused themes as needed.

At the end of every seminar, FoPM students have the chance to talk directly with the speakers and ask questions. It is not uncommon for students to be overjoyed at the unexpected discovery that they are talking to someone who graduated from their own laboratory.

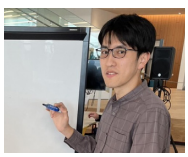
At the International Career Seminar. The wide variety of guests inspires many questions.

Alumni Q&A # 2

Messages from FoPM Alumni

For smooth communication with other departments

Q: What is your strongest memory of FoPM?
A: Listening to talks from researchers in various fields at the 4PM Seminars.
Q: What has been useful for your career?
A: The ability to carry out research independently, which I developed as a FoPM student, is also useful in my current workplace.
Q: How was the interdisciplinary exchange?
A: I have become better at considering differences in values and research fields, which helps when I am communicating with engineers from other departments.



Department of Physics
Hiroaki Tanaka
Current affiliation: Research Center for Computational Science and Informatics, Resonac

Interdisciplinary exchange is training for the workplace

Q: What is your strongest memory of FoPM?
A: The month I spent in the Netherlands. I visited a professor with whom I had no previous connection and learned a lot from the experience.
Q: What has been useful for your career?
A: The lectures on academic writing and data analysis. I have changed disciplines, but the fundamentals are still relevant.
Q: How was the interdisciplinary exchange?
A: Participating in discussions with people from a wide range of research fields has helped me a lot in the workplace.

Department of Applied Physics
Ryota Yambe
Current affiliation: Research Center for Computational Science and Informatics, Resonac

Beyond Borders

The Power of FoPM 03

Realize the dream of doing global research with FoPM

Every researcher dreams of working with outstanding scientists from around the world to enrich their research and discover the latest knowledge. If they can do it while still a student, so much the better.

To train globally minded individuals, FoPM requires students to carry out collaborative research at an overseas university or research institute, or to participate in a corporate research internship abroad. The International Career Seminar encourages students to acquire a broad perspective regarding their future career, whether they hope to be in Japan or abroad, in academia or elsewhere. Each year, PhD holders active in a variety of sectors are invited to talk about their experiences and act as role models for current students.

Faculty members must also realize their role in helping students to achieve their dreams, and the program offers guidance on writing recommendation letters at the level expected by the international community.

Keywords

1. International Research Experience
2. International Career Seminar
3. Faculty Development

1. FoPM students are required to gain research experience at an overseas university, research institute, or company between the 2nd year of the Master's program and the 2nd year of the Doctoral program.

2. Alumni and other PhD holders are invited to the International Career Seminar as role models to introduce students to the diversity of careers open to Doctoral graduates. This encourages students to consider their future career paths from a variety of perspectives.

3. To maximize each student's career potential, faculty members must be able to write recommendation letters that conform to the international standard and are trusted by external parties. FoPM provides specific guidance on the expectations of the international community in faculty development workshops.

Turn the page for interviews with FoPM students

Seeing overseas postdocs enthusiastically tackle their research ignited my passion

Sakakibara spent 3 months in the US to do research using a one-of-a-kind electron microscope at Lawrence Berkeley National Laboratory. First time living abroad, first time living alone. What are his valuable takeaways from this experience?

Above all, the experience ignited my passion for research

——What was the purpose of your stay at Lawrence Berkeley National Laboratory?

The laboratory I am a member of in the Department of Chemistry uses electron microscopy to tackle unresolved mysteries. For example, atoms are arranged in a neat periodic structure in crystals. However, the timing when the atoms spontaneously come together to form this periodicity is not yet known. Clarifying it is one of my research topics. As a concrete step, I am investigating the effects of thermal fluctuations on "selecting" the structure of the forming crystals. What I enjoy about this kind of experimental chemistry is that we can see the phenomena in action under the microscope with our eyes, and that gaining a successful understanding of the phenomena depends entirely on our efforts.

I went to Lawrence Berkeley National Laboratory, or "Berkeley Lab," because they have a unique electron microscope. The electron microscopes we currently use in Japan can only be used to observe things in a vacuum. However, I felt that in addition to the research I was already doing, it was necessary to observe the actual crystallization process in aqueous solutions. At that time, I learned that Professor Haimei Zheng of Berkeley Lab was working on observations in solution using electron microscopy, and later, I got the chance to meet her at an international conference. I asked if I could visit her lab, and she kindly agreed. So, I spent 3 months there. The main purpose of my stay was to observe phase transitions in solution.

——Was it a fruitful experience?

Absolutely. It was my first time living abroad for an extended period. It was also my first time living alone as in Japan I was still living at my parents' house (laughs). The students at the laboratory I was visiting were incredibly kind and helped me out via email even before I arrived. For me, the biggest takeaway was seeing up close how enthusiastically the lab's amazingly talented postdocs were tackling their research. It was very inspiring to see their willingness to ask questions and discuss research outside their own fields. I met and had discussions with Prof. Zheng every day. She took research very seriously and was strict with lab members, but once we stepped out of the lab, she was very spirited and friendly.

——Has the experience changed you in any way?

I think I have changed a lot thanks to this experience in the US. First, I am no longer afraid of living alone (laughs). Above all, the experience ignited my passion for research. I could not finish everything in 3 months and wanted to stay longer to do more research. I even started to think that a job abroad as a postdoctoral researcher or laboratory staff member could be a possible future career option.

I think staying abroad for an extended period and working on a project with people from other countries is worth a try for any student who has been doing research in Japan for a long time but is thinking about being active, academically or socially, on the international stage.

Third-year Doctoral Student, Department of Chemistry

Masaya Sakakibara

Sakakibara entered the University of Tokyo after graduating from high school in Tokyo in 2016. He joined the Nakamura Laboratory in the Department of Chemistry, School of Science, in 2019. His research interest is exploring the mechanisms of phase transition phenomena using transmission electron microscopy.

I started to think a postdoc or laboratory staff job overseas could also be a future career option.

A daily roundtrip to the observatory at 5000 m and back—oxygen tanks required

Her destination: Chile in South America. More precisely, the Atacama Desert, one of the driest places on the planet.
Her mission: Prepare and conduct a test run of a large telescope called Polarbear-2b near the summit of Cerro Toco.

I was moved to see the telescope with my own eyes

——How did you find your International Research Experience in the Atacama Desert in Chile?

The precise location of my visit was the observatory near the summit of Cerro Toco in the Atacama Desert. This observatory is run by a large-scale international collaboration called the Simons Array project. I took part in the preparation and test run of the Polarbear-2b telescope at 5000 meters above sea level. We stayed at a hotel at a lower altitude——still at about 2400 m——that was nearly an hour ride in a pickup truck going up and coming down each day after work. At that altitude the temperature drops below freezing even during the day, and we had to carry oxygen tanks, cover our faces with neck warmers, hats, and sunglasses to protect us from the strong ultraviolet rays, and wear mountaineering boots and shoes. It required a certain amount of physical strength, but working alongside Chilean and American collaborators, I did not find it hard. If anything, I enjoyed it. I was the only Japanese person on the staff, but I became close with everyone as we always ate and worked together. It was a rewarding month-long stay.

——Why did you want to go to Chile?

The Simons Array project studies electro-magnetic waves coming from space, with a focus on the polarization of millimeter waves. The observations provide clues to the beginning and the history of the universe. Polarbear-2b is a large telescope consisting of a combination of mirrors, lenses, and detectors, and plays a crucial role in these observations. It needed to be assembled at the site before it could be used. I wanted to go to Chile to be involved in and experience its construction firsthand.

The optical elements mounted on the telescope are key for our research. Our mission in Chile was thus to mount and activate elements developed in the lab on the telescope at the observatory. We also established methods for analyzing the data obtained and conducted actual data analysis. Seeing the telescope in the field was a memorable experience. I was very moved to think that this telescope is the result of the steady research that has gone into its construction by collaborators from all over the world.

I am now in Japan analyzing observation data from Polarbear-2b. The data, nothing more than a list of numbers, could also only be obtained through the efforts of many people. For example, just connecting a single cable was a struggle. I do not think I would have appreciated this if I had not actually been there.

——What kind of research do you want to do in the future?

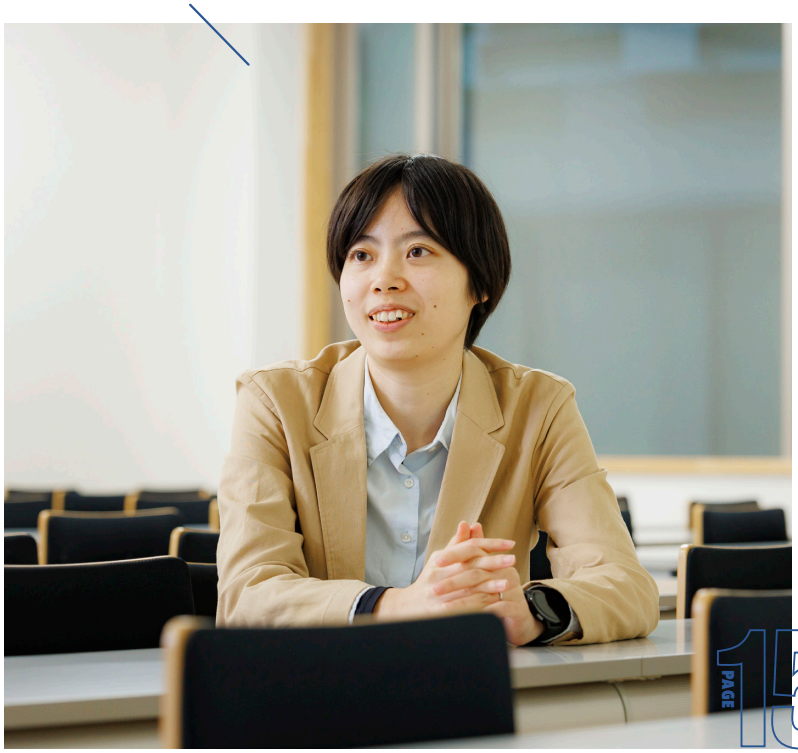
I am currently studying the rarely observed circular polarization of radio point sources. I believe this research may provide clues to the discovery of fascinating new phenomena. Not just developing the elements in the lab but going on-site has been a challenge. But in all, it has been fun and rewarding. By continuing to make observations of physical phenomena, I hope to contribute to exploring the beginning and history of the universe.

Third-year Doctoral student,
Department of Physics

Kana Sakaguri

After graduating from high school in Tokyo in 2016, Sakaguri majored in physics in the Faculty of Science at Kyushu University. She has been a member of the Kusaka Laboratory in the Department of Physics, School of Science, since 2020. As an observational physicist, she specializes in the polarization of millimeter waves.

The data, nothing more than a list of numbers, can only be obtained through the efforts of many people.



AI & Quantum Computing

The Power of FoPM 04

Learn the common scientific knowledge of the next generation

FoPM believes that the next generation of researchers will need an understanding of AI and quantum computing, and students are thus required to take courses in at least one of these subjects.

Students can take advantage of the Japan–IBM Quantum Partnership formed by IBM and the University of Tokyo to get hands-on experience on IBM Quantum System One——the world's first gate-model commercial quantum computer——in collaborative study and research.

Those who choose courses in AI will learn the basics of artificial intelligence, from necessary programming skills to big data analysis techniques and the fundamentals of neural networks.

Studying the future of AI and quantum computing will boost each student's own future potential.

Keywords

1. IBM Quantum System One

2. Data analysis and programming

1. Under a partnership agreement between IBM and the University of Tokyo, FoPM students have access to the state-of-the-art quantum computer, "IBM Quantum System One." The current model is equipped with a 127-qubit Eagle processor and is installed at the Kawasaki Business Incubation Center in Kawasaki City, Kanagawa Prefecture.

2. Information processing skills have become indispensable as a result of the rapid spread of AI and other new technologies. In FoPM's AI Course, students learn about big data analysis and data mining by carrying out programming assignments. This experience provides students with the skills needed to contribute to the development of next-generation AI.

Turn the page for interviews with FoPM faculty members →

AI: A revolutionary tool for research

Jia Liu is the director of the Center for Data-Driven Discovery (CD3) at Kavli IPMU. She encourages students to study AI for two reasons: it will accelerate their research and broaden their career horizons.

With AI, we can go beyond what humans can do

——How are you implementing AI in your research?

My work aims to answer fundamental questions in physics, such as the origin of our universe, the nature of dark energy, and the total mass of neutrino particles. I use cosmological observations of the cosmic microwave background and galaxies, together with state-of-the-art numerical simulations. I mainly use supercomputers in Japan, such as the Fugaku supercomputer, and in the US to conduct my research.

I started integrating AI into my research several years ago as a way to accelerate my work. AI has the advantage of recognizing patterns invisible to the human eye, which may be particularly interesting for cosmology. For example, the patterns in the distribution of galaxies may hold the secret to understanding the origin and fundamental laws of our universe. Luckily, tools developed in the industry to distinguish cats from dogs can be directly applied to studying the cosmos. My work has benefited from the explosive development in AI over the past decade.

——Why do you think students should study AI?

The study of AI is invaluable for FoPM students as it enhances their research capabilities and prepares them for a rapidly evolving academic and professional landscape. AI enables the analysis of vast datasets, the creation of predictive models, and the automation of repetitive tasks, making research more efficient and productive.

AI's interdisciplinary nature allows students to apply its principles across various domains, fostering collaboration and innovation. It equips students with highly sought-after skills in both academia and industry, enhancing their career prospects. By being part of the AI revolution, students can also contribute to the responsible development of AI and positively impact society.

——What are some of the ways you are planning to apply AI in the future?

I am currently affiliated with Kavli IPMU (Kavli Institute for the Physics and Mathematics of the Universe), where I serve as the director of the Center for Data-Driven Discovery (CD3). At CD3, we are working to understand why artificial neural networks perform so well, using tools developed in the physics community, such as quantum field theory and statistical mechanics. In addition, we are investigating the potential of AI to accelerate scientific discovery.

In our "Human–AI Collaboration" program, we gather scientific ideas from CD3 members on broad topics——such as particle physics, astrophysics, cosmology, mathematics, high-energy physics, and social science——and pair humans and AI to conduct parallel research on each project. By the end of the program, we aim to deliver a framework for evaluating AI in scientific research, a comparative analysis of AI and human research capabilities, a report on ethical and social implications, and recommendations for future human–AI collaboration in scientific research.

Project Associate Professor, Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU)

Jia Liu

Liu received her PhD in Astronomy from Columbia University in 2016. After postdoctoral fellowships at Princeton University and the University of California, Berkeley, she assumed her current position in 2021. She has also been Director of the Center for Data-Driven Discovery at Kavli IPMU since 2023.

AI can find specific patterns invisible to the human eye. This has revolutionized my research.

Studying quantum computing is studying to protect the environment

Akira Furusawa is a pioneer in the field of optical quantum computers. He is sure to revolutionize the history of computing, and the world is watching his every move. What does he have to say about the importance of studying quantum computing?

Quantum computing is of civilizational importance

——What impact will the optical quantum computer, which you aim to commercialize, have on society?

The essential goal of computing is to develop the ability to process information like the human brain. Human brains and neural networks are both analog systems. The information in wave functions is also analog, not digital. As such, the properties of quantum systems can truly be exploited only by an analog, and not a digital, computer. Therefore, the crucial aspect of the computer that I am developing is that it is an analog quantum computer, unlike the digital quantum computers developed by IBM Quantum and others.

I believe that Richard Feynman was the first person in the world to conceive of a quantum computer. He was thinking about what kind of computer would have the lowest energy consumption. From the point of view of the thermodynamics of computing, he concluded that it would be a quantum computer. In other words, rather than considering only computing speed, our aim should be to create a quantum computer that consumes very little energy, like the human brain, which can keep running on a single rice ball.

Digital computers consume large amounts of electricity. According to some estimates, they are responsible for more than half of global energy consumption. So, computers are also a driver of climate change. Our approach is completely different from that of conventional digital computers, with our ideas based on quantum teleportation with classical communication at the root. Processing is done in analog, and the only digital aspect is the code used. We have successfully built such an analog optical quantum computer and will complete the first commercial machine this year (2025).

—— A computer that can protect the environment?

All facets of modern industry and infrastructure are supported by computers. However, continuing to use digital computers, which consume huge amounts of energy, may lead to environmental collapse. In that sense, it is fair to say that research on analog quantum computers will help protect the environment and is thus of civilizational importance.

——Why do you think students should study quantum computing?

No field in the natural sciences is completely disconnected from quantum physics. Chemistry and mathematics, in particular, are solely in the domain of quantum computers. To begin with, chemical structures consist of superpositions of quanta, so chemical simulations can only be done with quantum computers. Consequently, precise scientific calculations cannot be done without quantum computers in pharmaceutical research, either. The same is true for astronomy and other fields. Because one has to deal with superpositions of states to research any phenomenon, the ultimate simulation can only be done on a quantum computer. Since everything is a quantum system, a classical computer cannot do such simulations. This means that everyone needs to learn quantum computing. It will surely open a wide range of future career options as well.

Everything is a quantum system. Thus, the ultimate simulation can only be done on a quantum computer.

Professor,
Department of Applied Physics,
Graduate School of Engineering

Akira Furusawa

Furusawa graduated in 1984 from the Department of Applied Physics at the University of Tokyo and received a Master's from the same department in 1986. After working as a visiting researcher at the California Institute of Technology and an assistant professor in the Department of Applied Physics at the University of Tokyo, he assumed his current position in 2007. He has also been Deputy Director of the RIKEN Center for Quantum Computing since 2021.

Entry Requirements

Eligibility

- You must be a student who has been accepted into or already enrolled in one of the following departments at the University of Tokyo
- You must also be aiming to acquire a Doctoral degree from one of the following departments at the University of Tokyo
  - » Graduate School of Science: Department of Physics, Astronomy, Earth and Planetary Science, or Chemistry
  - » Graduate School of Engineering: Department of Applied Physics
  - » Graduate School of Mathematical Sciences: Department of Mathematical Sciences

* Students planning to find business employment after finishing their Master's degree are not eligible to apply to FoPM.

Graduation Requirements

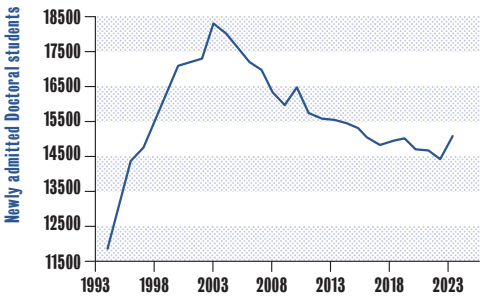
- Elective coursework (8 credits), including courses in
  - » Academic writing and presentation
  - » AI and/or Quantum computing
  - » Social issues and innovation
- Diversity and Ethics Training
- Discussions with secondary supervisor
- Lab Rotation
- 4PM Seminar
- International Research Experience
- International Career Seminar

Application guidelines
https://www.s.u-tokyo.ac.jp/en/FoPM/application/guidelines.html

FoPM Support Fund

Support the future drivers of change in Japan and beyond

In recent years, Japan's lack of financial support for Doctoral students, coupled with unstable employment for early-career researchers in academia and the deep-seated reluctance of Japanese industry to hire Doctoral graduates, has held outstanding Master's students back from continuing their studies to the Doctoral level. As a result, and in direct contrast to the global trend, the number of newly admitted Doctoral students in Japan has been in constant decline since its peak in 2003.



Graph created by FoPM staff on the basis of data from "Japanese Science and Technology Indicators 2024", NISTEP RESEARCH MATERIAL, No.341, National Institute of Science and Technology Policy, Tokyo.

By maximizing the potential of each individual student, FoPM aims to train Doctoral graduates who have both a strong grounding in basic science and the disposition to take on any challenge. Because they have a firm grasp of the fundamentals of mathematics, physics, and chemistry, this kind of 'STEM talent' can become anything they choose. We have great expectations for our students, perhaps a future Nobel Laureate or Fields Medalist, or someone who will greatly influence national politics is among them.

We greatly appreciate your generous support for our endeavor to train Doctoral graduates who will drive change and contribute to a better world.

More details (in Japanese)
https://utf.u-tokyo.ac.jp/project/ptj149

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Message from the FoPM Program Coordinator

Students with the skills to discover new knowledge can change the world

University Professor
Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU)

Hitoshi Murayama

When you start a PhD, others often ask "why do you want to study so much?" But I think your aim is rather to find your own path and maximize your potential for the future benefit of humanity. Do you want to make breakthroughs in your academic field? Create a new business model in industry? Change society by starting a new company? Create a new future in government? Start out on a completely new journey in another country? Or even change the fate of our planet? No matter which path you choose, you are sure to discover a new stage for humanity.

FoPM helps you to discover your own path of maximum potential by bringing students together from a variety of disciplines. Be exposed to research and current issues in other fields in the 4PM Seminar and Lab Rotation. Study AI or quantum computing to develop vital skills needed for any future career. Experience a whole new culture by doing research abroad. Open your eyes to new opportunities in the International Career Seminar. Develop crucial communication skills in Academic Writing and Presentation courses. Experience the thought processes in industry and join workshops on entrepreneurship. Increase your awareness of the problems faced by humanity in courses on the SDGs. Understand the issues surrounding diversity so that you can become a true leader and maximize the potential of those around you. FoPM offers you all this and more.

Coming back to the original question, "study" is to internalize what is already known. "Research" is to discover new knowledge that nobody in the world has known before. Once you can do this, you have the potential to literally change the world!