INSTITUTE FOR ADVANCED RESEARCH

LETTER

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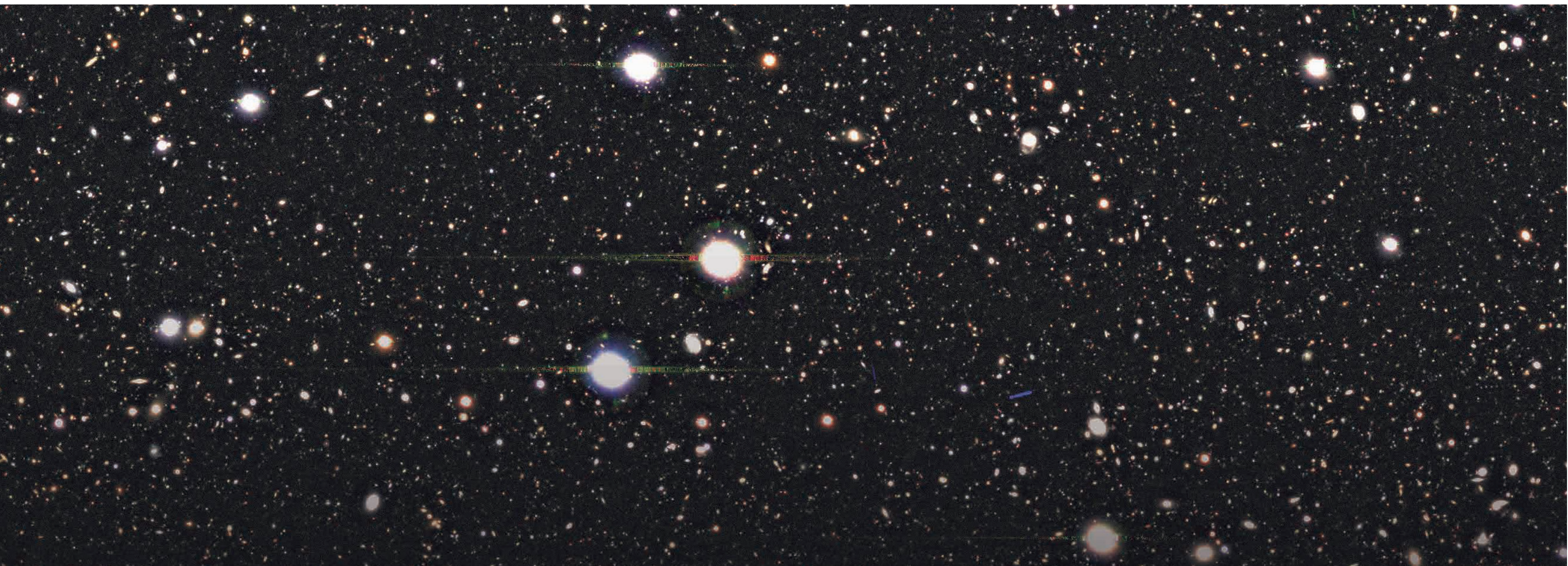

Special Interview

Investigating the origin of the Universe
－Research about formation of structures in the Universe from Big Bang to present－

Naoshi Sugiyama

Research Highlights

INSTITUTE FOR ADVANCED RESEARCH
NAGOYA UNIVERSITY
SINCE 2002
高等研究院
名古屋大学

NAIAS
名古屋大学 国際高等研究機構
Nagoya University
Institute for Advanced Study

NAGOYA UNIVERSITY

Toward Further Academic Advancement in the COVID-19 Era

"If it be judged useful by those inquirers who desire an exact knowledge of the past as an aid to the interpretation of the future, which in the course of human things resemble if it does not reflect it, I shall be content." So envisaged Thucydides the value of his great historiography written more than 2400 years ago. It is now certain that he was definitely right. In early 2020, his vivid description of the disastrous situation of plague-ridden Athens in 431 BCE was suddenly translated into reality for all of us who had never seriously dreamt of the ever-threatening menace of pandemic.

Concerning the activities of our institute, an ominous sign was the postponement of UBIAS Directors' Meeting in March 2020 at Marseille. With the start of a new academic year in April (an academic year in Japan starts in April and ends in March), other activities of our institute were also suspended or obliged to be held online. One of the most important events of our institute, the Nagoya University Lecture, which was scheduled to be held on November 14, was cancelled at the last minute because of the confirmed cases inside the university campus. We must admit that the coronavirus pandemic is provoking serious problems in our daily and academic life, and now we fully realize the true value of face-to-face communication and especially lively conversations over drinks after conferences. But it must also be true that we should regard the current circumstance as a great and precious challenge to change our traditional and conservative way of thinking.

The year 2020 marked the 10th anniversary of the UBIAS consortium, which has successfully developed close collaboration of leading Institutes of Advanced Study (IAS) around the world. On this occasion, we, together with Nanjing IAS, proposed "Dialogue" as the Topic of the Year (ToY) for 2020. Although confusions and difficulties caused by COVID-19 seem to continue well into 2021, it is beyond doubt that dialogue remains essential to conducting interdisciplinary research and cutting-edge scientific explorations. It is thus our great pleasure to confirm that the UBIAS steering committee unanimously agreed to adopt "Dialogue" as ToY for 2021 as well. The importance of dialogue will never be shaken even after the pandemic. On the contrary, dialogue will become more multifaceted as we begin to experience it now online thanks to the development of information technology. We sincerely hope that dialogue may further strengthen the partnerships among the UBIAS members and other institutes of leading research universities in order to promote more brilliant academic advancement in the COVID-19 era.

Yoshiyuki SUTO
Director, Institute for Advanced Research

Director
SUTO, Yoshiyuki

19
March 2021

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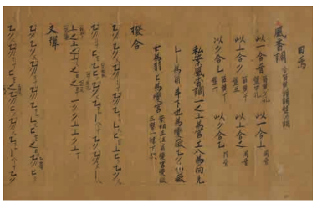
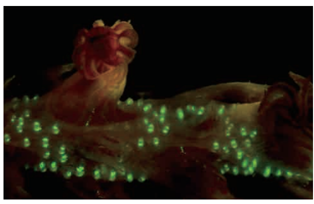
CONTENTS

Cover Picture :
Deep sky image taken by the Hyper Suprime-Cam mounted on the Subaru Telescope at the Mauna Kea mountain summit on the Island of Hawai'i.
(Photograph of Daichi Kashino, YLC Assistant Professor. See page 09.)

Special Interview

Naoshi Sugiyama

Dr. Sugiyama was born in 1961 in Germany.
He is a professor at the Graduate School of Science. He also has been provost of Nagoya University since 2019 and served as a trustee of the Tokai National Higher Education and Research System since 2020. As a cosmologist and a leader of the world project with telescopes, Dr. Sugiyama is working to elucidate the dark matter and the universe's origin. He received his doctorate (in science) from Hiroshima University in 1989. He designated an Assistant professor at the University of Tokyo in 1991, and an Associate Professor at the Graduate School of Science, Kyoto University in 1996, a professor at the National Astronomical Observatory of Japan in 2000 before taking on his current positions in 2006. Since April 2020, Dr. Sugiyama has been the Director of Nagoya University Institute for Advanced Study (NAIAS).

Investigating the origin of the Universe
– Research about formation of structures in the Universe from Big Bang to present –

—— Dr. Sugiyama, you are a cosmologist, a Trustee of the Tokai National Higher Education and Research System, and the Provost in charge of Supervision and Research at Nagoya University. In this interview, we would like to ask you questions about your career as a researcher in the first half and about university administration in the second half. First of all, how did you first come to think of becoming a research scientist?

SUGIYAMA: I was born in 1961 in Germany, where my father had been a research fellow in the university, and I grew up in Kunitachi City, Tokyo, and Kawasaki City. As a child, I was a serious bookworm, the kind who would check out every single book from the library. I also enjoyed playing the piano and the flute. While reading scientific books, I came to think that physics, in which one studies the principles of nature, would be an interesting way to try to understand this world. I had the audacity to write for my middle school's graduation essay collection "I will be a physicist and win the Nobel Prize" (laughs).

—— You first entered the Department of Physics in the Faculty of Science and Engineering at Waseda University.

SUGIYAMA: Yes. In my senior year, I joined Prof. Mikio Namiki's research unit on elementary particles. He was a lofty scientist who didn't flock. He taught us not to imitate others or follow fads in research. I continued to graduate school. That was exactly the time when physicists had begun talking about how dark matter formed structures in the Universe. I became interested in understanding the Universe, in particular, the formation of a variety of structures in the

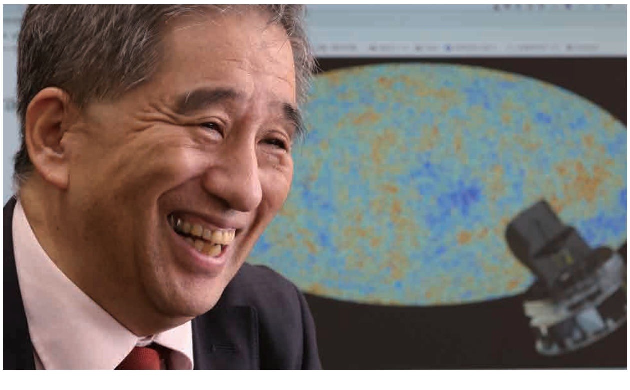
Universe. This interest originated from my research about dark matter particles from the perspective of elementary particle physics. Unfortunately, there were no professors specializing in the subject at Waseda, and in those days it was virtually impossible to transfer to another university at the doctoral level. So I was at a loss what to do for a while until I learned by chance that there was a vacancy for a doctorate student in cosmology at the Research Institute for Theoretical Physics of Hiroshima University. I was allowed to take the exam to transfer.

—— Could you explain to us briefly the cosmology that you started in the doctoral course?

SUGIYAMA: It is a discipline that studies the origin and history of the Universe as a whole. In this discipline you focus persistently on the Universe as a whole, not on individual celestial objects such as galaxies and stars. When I look back on my life as a researcher, encounter with people has played an enormously important role. At Hiroshima University, I had the good fortune of meeting Profs. Hidekazu Nariai and Kenji Tomita, who were doing highly original research in cosmology. Moreover, almost at the same time as my transfer to Hiroshima, a very talented young researcher named Misao Sasaki arrived there. He and Kenji Tomita, both Associate Professors at that time, gave me a research theme, which was to study the formation of structures in the Universe through fluctuations, that is, bumps and wiggles of densities that were made during the early phase of the Universe. It is understood that those fluctuations have developed into galaxies and other structures, held together by gravity over a period of 13.8 billion years. In the Universe, there are essentially dark matter, light, and ordinary matter, which interact with each other to form structures. Dark matter is invisible, but it forms and supports visible structures in the Universe, such as galaxies and galaxy clusters. The visible parts of galaxies and galaxy clusters are composed of ordinary matter, that is, elements. Elements have been attracted to the gravity of dark matter and formed stars, galaxies, and galaxy clusters. In the Universe, light also interacted with matter through scattering and by gravity until approximately 380,000 years after the Big Bang. My research involves theoretically predicting how this light has since split to be observed today and what information can be drawn from that. The light that we can observe today is called cosmic microwave background (CMB) radiation.

—— So we can say that your main research interest is the study of CMB.

SUGIYAMA: CMB is a microwave emission that is observed almost isotropically from all directions in the sky. A microwave is a type of short-wavelength radio wave, that is, an electromagnetic wave, a form of light. As I have said, this light formed "bumps and wiggles" together with elements and dark matter for about 380,000 years following the birth of the Universe. Until this epoch, light strongly interacted with electrons and protons, which formed atoms. At that point, light was separated from other components and has freely traveled in the Universe. This is to say, CMB has carried information from the time of the Big Bang directly to us. In other word, we can say CMB is the fossil of the Big Bang. The existence of this radiation was confirmed in 1965. But the bumps and wiggles, which should be in the radiation since they come from the same origin as structures in the Universe, were not found. When I was a graduate student, I thought that they would be found one day for sure because, in theory, they absolutely exist. So I decided to do research to thoroughly predict what could be learned when they were discovered. For example, the type of dark matter should change the pattern of bumps and wiggles. I realized that, at the time when nobody believed that there was dark energy in the Universe, by incorporating it into theory it was possible to make predictions about structures and the age of the Universe with no contradictions from observed results. I was deeply moved at that time.



—— And sure enough, fluctuations were really observed...

SUGIYAMA: I obtained my doctorate in 1989, and that was a time when space observation began to progress really rapidly. The Hubble Space Telescope was launched in 1990. In 1992, I was working as a postdoc assistant in Prof. Katsuhiko Sato's laboratory at the University of Tokyo, when NASA's COBE (COsmic Background Explorer) found fluctuations in the cosmic microwave background for the first time. I was ecstatic when I realized that what I had predicted really existed. We were very proud that our paper on constraints on cosmology, which we wrote using COBE's results, was published before they were published in the same scientific journal. We managed this feat because we wrote up our paper in a few days after obtaining a preprint of the results by fax, as it was done in those days, and sent the paper in immediately. The principal COBE researchers received the Nobel Prize for their achievements in the COBE project in 2006.

After this, I went to UC Berkeley to continue my research with Prof. Joseph Silk and his graduate students and postdoc researchers there, examining what can be systematically understood from the pattern of fluctuations in observation results. Since COBE's results, theoretical research has progressed remarkably, resulting in a succession of satellite project proposals. The United States launched the WMAP (Wilkinson Microwave Anisotropy Probe) in 2001, and the European Space Agency launched Planck in 2009. I will never forget the moment when the detailed spatial pattern of fluctuations released by WMAP around 2003 perfectly matched our prediction. Exact correspondence between the data observed by the satellite and our prediction with adjusted theoretical parameters was a major triumph for us.

—— What lessons did you take away from your years abroad?

SUGIYAMA: I made a huge progress in my research while I was abroad because I had a lot of time to spend solely for research. This experience drove home to me that for young researchers, time secured exclusively for research is far more important than research funds, for example. In natural sciences, it's usually the case that you produce good research results when you are young. You wouldn't be able to continue as a researcher, however, if you didn't solidify the core of your research while still young. I also learned the importance of the environment. UC Berkeley was a special place. You would be working in the computer room, and the person seated behind he could be a Nobel laureate. During a seminar, a discussion would suddenly begin, and you could recognize the persons speaking up from your college textbooks. I remember Prof. Silk having coffee at an outdoor café every afternoon, discussing research with postdocs and visitors from all over the world. There were many researchers on the campus, and the atmosphere there really encouraged us to interact with one another.

Changing your environment, which is not just limited to going abroad, has a positive impact on researchers because something different begins in a new environment.

—— Upon returning to Japan, you worked as an Associate Professor at Kyoto University and then a Professor at the National Astronomical Observatory of Japan before arriving at Nagoya University in 2006. What are your current research themes?

SUGIYAMA: At present, my research group is mainly involved in three projects. One project is theoretical research as the main Japanese participant in an international project called SKA. This project involves building radio interferometer telescopes that fill a site of about one square kilometer in Australia and South Africa to find out how the first stars were made and how stars and galaxies are formed in the Universe.

The second project involves the Subaru Telescope in Hawaii. We use a new ultra-wide-field camera to precisely measure the shapes of galaxies in order to examine, among other things, the distribution of dark matter, which deforms the shapes of galaxies due to the lensing effect. We also use data mining and other technologies.

The third project is also about the early universe. We are studying cosmic inflation, how the Big Bang occurred, and how various events in the early universe have affected the results of present-day observations.

At the moment, we're using competitive funds to actively hire many young people to work in the group. We are a unit of about 10 academic faculty members and postdoc researchers and some 20 students. It's a large research unit for cosmology by international standards.

—— It seems that not only your research but laboratory administration is going very well.

SUGIYAMA: I have been most strongly inspired by the Berkeley style: only a few tenured professors but many postdocs who are among the world's best. It is best to get young researchers heavily involved, getting them to do quality projects and write papers at the appropriate time. I also encourage postdocs, and designated faculties of our group to work with graduate students. When one gets students to work with, one can't be unclear about anything because students keep asking about everything. So one has to work harder, which broadens and deepens one's understanding. Naturally, this further stimulates the students. This is the best way to foster both students and postdocs, I believe.

—— Now that you have touched on managing your research group, we wonder why you have come to get involved in university administration while you are quite enthusiastic about your research.

SUGIYAMA: The turning point came in around 2008, when our research unit at Nagoya University in the domain of elementary particles and astrophysics applied for designation as a global COE (Center of Excellence) as part of a national project. I was the representative applicant for our unit, whose research theme was the exploration of fundamental principles of the Universe. I wrote up a rock-solid Q&A script with all the questions that I anticipated the screening jury would likely ask. As a result, our project was adopted. That was for 5 years' project whose annual budget was approximately 200 million yen. You see, I work in cosmology, which sounds like a dream-like domain, but I'm also a very realistic person (laughs). For this project, I also concretized my idea of leadership. I put a reliable person at the head of each section and let them take the lead on a day-to-day basis, but I make sure to meet with the leaders regularly so that I can manage the overall affair while taking full responsibility. Things went very well this way. Looking back now, I think it's exactly a method of shared governance.

Through this project, I got to know the executive division of the University, which led me to serve as an Advisor to the President. As I made various proposals about where Nagoya University could be improved, how it needed a branding strategy, and so on, I was appointed representative of the national project called "Program for Leading Graduate Schools," which is aimed at training young leading researchers regardless of whether they are humanities or scientific majors. I also served as the Deputy Director of the Institute of Advanced Research of Nagoya University. At around that time, I began to have less time for research, but on the other hand, I have come to realize how important and meaningful university administration is by learning from seminars for candidate university administrators from all over Japan through the university design workshop organized by National Graduate Institute for Policy Study. After working as the Dean of the Graduate School of Science, I have been a Trustee of Nagoya University and the Tokai National Higher Education and Research System since 2019.

—— What are the goals that Nagoya University is currently working towards?

SUGIYAMA: We want Nagoya University to be among the top 100 universities in the world in terms of research within the next 10 years. To achieve this, it is absolutely necessary that Nagoya be always at the world's highest level in particle physics, space sciences, organic chemistry, and automotive engineering, among other fields of research. We also want to contribute to industry and manufacturing to enhance social innovation. In this area, we have Toyota and many other related companies working for car manufacturing. It is time, however for this region to create next big industires after car manufacturing, which is one of missiongs of Nagoya University, I believe. I would love to see research develop in ways that lead to innovation, particularly in engineering and agriculture.

—— With regard to university administration, Nagoya and Gifu Universities established the Tokai National Higher Education and Research System (THERS) as the first Japanese national universities to integrate their operating corporations into an umbrella system that runs multiple national universities.

SUGIYAMA: We have undertaken something that enables us to do what a single university could not do otherwise due to Japan's declining birth rate. Nagoya University has the country's ninth largest student body, approximately 16,000 students. The THERS is the third largest, with a little over 23,000 students. The integration has brought us merits of scale in terms of budget and importance for the national government. We are envisaging a strong alliance between the two universities, including the integration of the administrative divisions, the schools of agricultural science, and more.

I want the two universities to reinforce each other's strengths and make up for each other's weaknesses. For example, Gifu University has a research center focusing on glycan, or, sugar chains. Nagoya University has many researchers working in the same field. They have joined Gifu's research center, and a new larger research center has emerged. The Japanese government highly evaluates the proposal of the new research center, the human glycome project, and has selected it for the MEXT's major research project called Road Map 2020. Collaboration in the field of aerospace technology also began to show positive results. A mechanism which allows one university to benefit from the other's educational contents and research achievements is coming into shape. We have established an organization called Academic Central, and preparation is already under way for the two universities to jointly organize undergraduate, especially liberal arts education.

It's not clear yet where the THERS will eventually land. Personally, I think it would be ideal if a third university and a fourth university join us, stimulating all universities to fully demonstrate their respective characteristics and add value to the overall presence.

—— The COVID-19 pandemic has put universities in a very difficult and complex situation. What responses are you making in this regard?

SUGIYAMA: When the infection began to spread in early March 2020, the executive division led by those in charge of educational affairs made the decision to switch to online classes immediately because the academic year begins in April in Japan. At present, online materials are always made available, even for face-to-face courses, in case there are students who prefer to attend classes online. For a period, we stopped everything, including research, banning undergraduates from coming to the campus in principle and allowing graduate students to come only when strictly necessary. Eventually, we began to obtain sufficient evidence to suppose that with correct measures infection would not spread in classrooms and laboratories. So now we pursue education and research normally, with careful anti-infection measures.

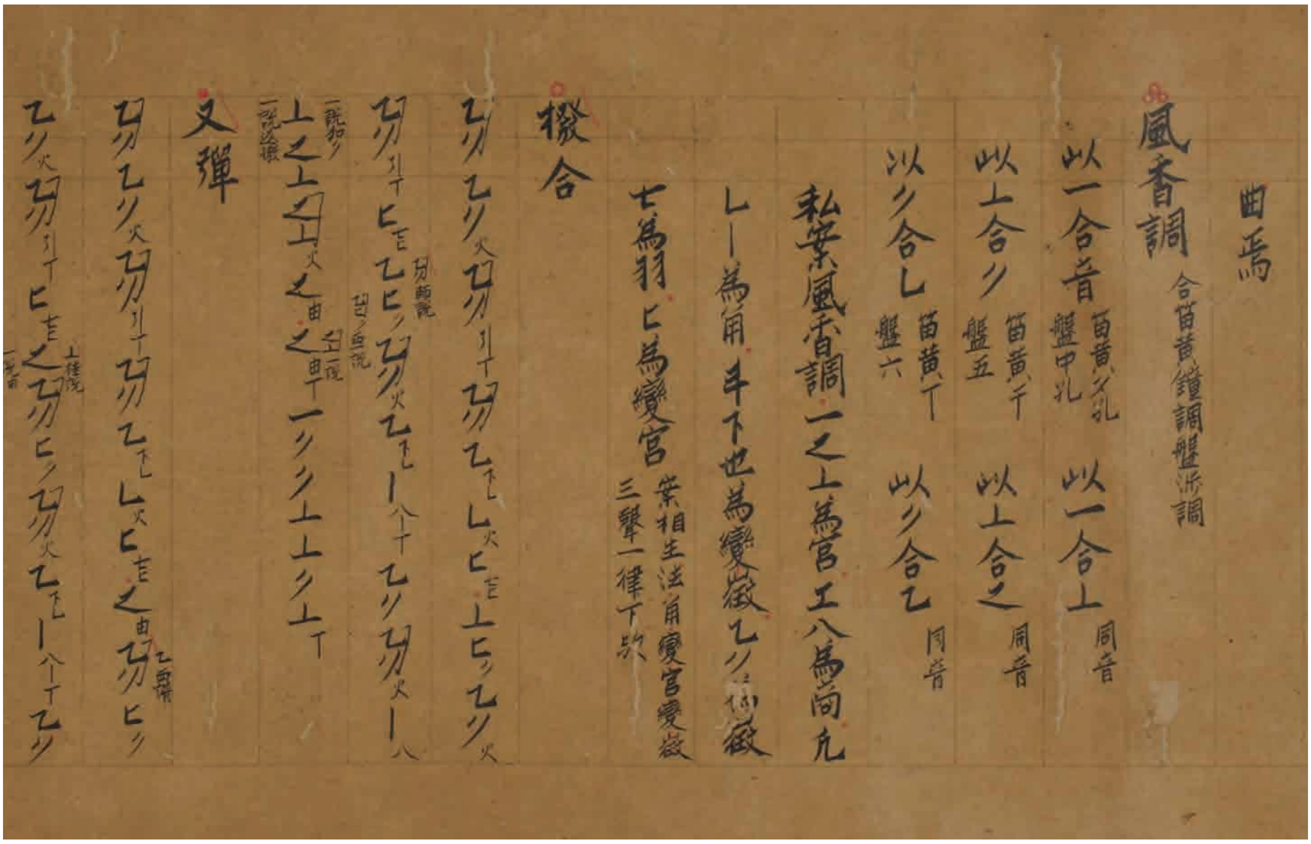
At the same time, this crisis has brought us some positive changes. For example, online platforms have made communication among university personnel closer and more frequent. Webinars have allowed many members of the academic faculties and administrative staff of Nagoya and Gifu Universities to discuss education, research, governance, international affairs, and many other topics and allowed the President and students to engage in direct discussions. This is something we were unable to do before. We still have problems to solve, such as how to expand these communication channels internationally. But for the moment, we are hoping to respond flexibly while taking maximum care to prevent infection and gathering everyone's wisdom to deal with education, research, and all else in the living-with-coronavirus mode.

—— Would you like to send a message to the students, including those who are preparing for admission to Nagoya University amid the pandemic?

SUGIYAMA: I am sure many of you are feeling quite lost, not being able to go to college as you would like to, due to the COVID-19 pandemic. For first-year students, in particular, I sympathize with your disappointment at the beginning of your new student life, which has seriously been upset. It was a good thing that we were able to organize classes online from the very beginning, although I don't think that the condition of online communication has always been completely problem-free, with some instructors having to grope their way. Still, I must say that, regardless of the public health situation, online classes make up an essential component of the digital university concept that we aspire to realize, and the current crisis has made us, on the side of university administration, become resolute in moving forward in that direction. As for the student side, I would like to see you continue tackling challenges, turning this crisis into a positive experience, with the unyielding spirit of courageous learned persons we all would like to be, persons with a solid base capable of bravely confronting all situations. The University will spare no effort in supporting you in this process. Let's overcome this corona crisis together!

Interview with Dr. Sugiyama was done by Nagoya IAR faculties and C. Ashihara (Chunichi Shimbun Co., Ltd). This interview article was written by C. Ashihara and translated to English under the responsibility of Nagoya IAR.

Restoration of Lost Music



This is score for biwa from the 14 century possessed by Kunaicho (Imperial Household Agency). First, the method of tuning is described, and then the name of the music and the score are described.

Chihiro INOSE

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Fujiwara no Moronaga was a great musician of the late 12th century. He transcribed various songs using Biwa score, which had been passed down by word of mouth in those days. I clarify the actual condition of transcription at that time and restore the lost music based on the scores written by Moronaga.

INTRODUCTION

My research theme is to find out how people in the past passed on their voices. Music vanishes from the moment it is played. We can hear neither the voices of the ancients nor the sounds they play. Goshirakawa-in, who devoted himself to imayō (popular songs of the time), wrote the following famous saying in "Ryojin Hisho Kuden shu" in the latter half of the 12th century:

The sad thing of the voice is, after I have collapsed, nothing of them remains.

He lamented that the sound and melody of imayō do not remain after his death. However, it is also true that through various methods, such as musical scores and oral instruction, some people tried to hand down their intangible music to posterity.

I examine the movement in the latter half of the 12th century in this paper, focusing particularly on Shōmyō (Buddhist chanting of Buddhist hymns) and its musical scores.

1. About Fujiwara no Moronaga

Fujiwara no Moronaga was the greatest person who recorded such intangible music. It is said that Moronaga tried to preserve various kinds of music as music scores as follows:

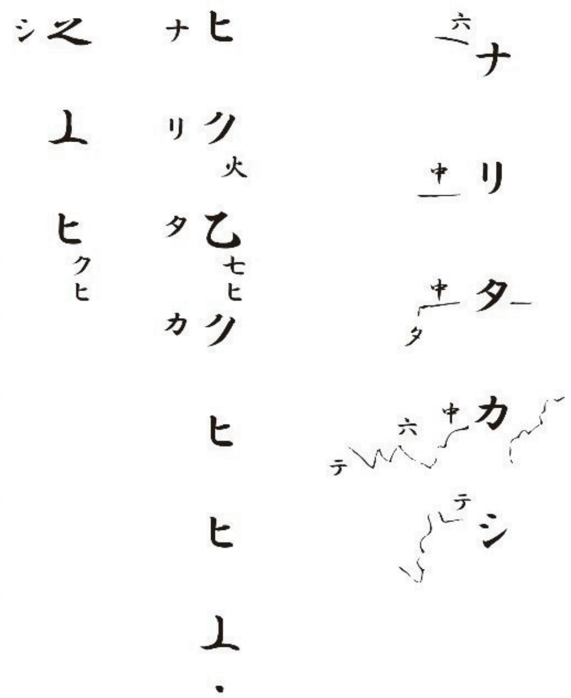
Moronaga, Grand minister of state, made imayō (popular songs) on the score of biwa, and later learned all the great songs.

"Ryojin Hisho Kuden shu"

Moronaga is known to have written the Biwa score "Sango Youroku" (12 Volumes) and the Koto-score "Jinchi Youroku" (12 Volumes). On the other hand, recent research has revealed that there are various scores transcribed by Moronaga.

2. Moronaga's scoring method

Moronaga scored according to the Biwa score. Biwa and Hakase scores were the main musical scores recorded in this period. The Biwa score comprises musical score with lyrics written on the left-hand side or the right-hand side. Each character of the musical score constitutes a chord (arpeggio), and the highest note of this chord becomes a basic melody. On the other hand, a horizontal line is written on the left-hand side and the right-hand side of the lyrics in the Hakase score, and the melody comprises the starting point and the angle of the horizontal line. It is characterized by its ability to express subtle heights by using wavy lines and curves. The Biwa score was largely created by nobles and the Hakase score by monks.



Left-hand side figure: Biwa score / Right-hand side figure: Hakase score

3. About "Shōmyō no Fu"

Moronaga also transcribed Waka and Fuzoku (a popular song in eastern Japan at the time) using this method. Among them, musical scores for Shōmyō are attracting attention. Shōmyō is a kind of Buddhist music and is characterized by its unique melodies. A score called "Shōmyō no Fu" is available in the Kunaichō.

There are three songs in this score: Buddhist scriptures, Kanshi (Chinese poetry), and Waka poems. The scriptures are quoted from "Lotus Sutra," which is the most widely known sutra in Japan. Kanshi is a quotation from "Monjusan." It is a poem to praise Manjushri. The famous poet BAI Juyi is an incarnation of Manjushri, and this "Monjusan" is thought to be a poem praising BAI Juyi as well. Waka is a quotation from "Takigi San," which describes the Buddha's previous life. Scripture originated in India, Chinese poetry in China, and Waka in Japan. Different languages are unified under Buddhist music.

It can be seen that each of the main elements of the court culture had a statement to praise Buddhism as described above and that this Buddhist music was transcribed by Moronaga. Moronaga included these songs in his Biwa score either because of the characteristics of the melody or because these Shōmyō scores were sung in many Buddhist rituals.

Cosmic Evolution of Galaxies and Baryons in the Universe

Figure 1. Deep sky image taken by the Hyper Suprime-Cam mounted on the Subaru Telescope at the Mauna Kea mountain summit on the Island of Hawai'i.

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The present-day universe is a rich world containing various elements, which have assembled into stars, galaxies, and living organisms. How have these elements and their composite matters evolved through cosmic time? Heavy elements are produced by fusion reactions inside stars, and stars form inside galaxies. Galaxies thus play key roles in the evolution of materials in the universe. Recently, I have become interested in understanding *cosmic reionization*, which is a major event that matter re-ionized after the end of the cosmic dark ages. We are carrying out dedicated observations using the world's largest telescopes, such as the Subaru Telescope, ALMA, and the *James Webb Space Telescope.* Herein I describe our ongoing projects and present our first result.

INTRODUCTION

The earliest stars and galaxies are thought to have formed in the first hundreds of millions of years after the birth of the universe. The period before the first objects formed is called the *dark ages*. After this period, the intergalactic gas (mainly composed of neutral hydrogen) filling the universe was gradually reionized by radiation from ancient astronomical objects. This process, called *cosmic reionization*, was the last major phase transition of baryons (i.e., ordinary matter) in cosmic history, and is thought to have been almost complete when the universe (currently 13.8 billion years old) reached an age of one billion years. Over the last decades, the technologies for astronomical observations have remarkably progressed, and the history of the universe is now largely understood. As one of the last remaining mysteries, reionization is among the most exciting frontiers of modern astronomy and cosmology.

To elucidate the process(es) of reionization, we must understand the properties of ionizing sources (stars, galaxies, and/or active galactic nuclei), the physical conditions of the intergalactic medium, and the interactions between galaxies and the circumgalactic gas. Reionization occurs when the radiation from nascent galaxies contacts the surrounding gas. The absorption features in the spectra of background distant quasars[1] are useful for probing the physical conditions of the foreground cosmic gas. Near the Epoch of Reionization, the remaining neutral hydrogen atoms absorb Lyα photons

(121.6 nm) and give rise to deep Lyα troughs in the spectra of the quasars, from which the opacity (or optical depth) of the universe can be measured. Interestingly, accumulated measurements of the effective Lyα optical depth have shown that spatial fluctuations in the opacity of the cosmic gas (i.e., the column density of the residual neutral hydrogen) increase dramatically near the Epoch of Reionization. The origin of these fluctuations, however, remains highly uncertain. The observations have been explained by different theoretical models, which must be verified by further observations.

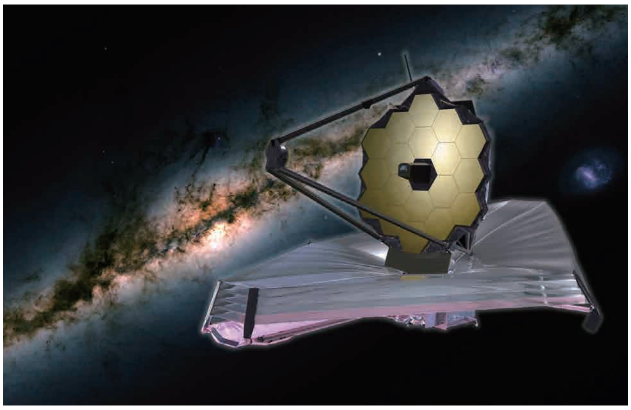

Figure 2. Image of the *James Webb Space Telescope*. Copyright: spacecraft image NASA; background image ESA/Gaia/DPAC, CC BY-SA 3.0 IGO

Furthermore, the absorption lines of metals (or *heavy* elements such as C, O, Mg, and Fe[2]) ejected by galaxies appear in the spectra of background quasars. The wavelengths of these absorption lines correspond to energy transitions of the elements. Measurements of the incidence rates and strengths of metal absorption lines have constrained the cosmic evolution of the metal-ion content in the universe. However, the gaseous processes occurring around the earliest galaxies remain largely unknown, as only very few host galaxies associated with metal absorbers have been identified.

The launch of the next-generation space telescope, the *James Webb Space Telescope* (*JWST*; Figure 2), will finally enable the spectroscopy of galaxies during the Epoch of Reionization. The exceptional high-sensitivity near-infrared spectrographs installed on *JWST* will obtain rest-frame optical spectra of very distant galaxies. From these spectra, we will investigate the star formation activities in these galaxies and the physical conditions of their interstellar gas. The advent of *JWST* and other forthcoming instruments is expected to revolutionize our understanding of reionization in the next decade.

RESEARCH OBJECTIVES AND OUR PROJECTS

We are attempting to comprehensively understand the evolution of galaxies and the cosmic gas in and near the Epoch of Reionization. To this end, we will combine the spectral data of distant quasars (which provide information on the gaseous components) with deep observations of ancient galaxies. In particular, we hope to elucidate 1) the origin of the spatial fluctuations in the optical depth of the intergalactic medium, 2) the evolution of metals in the intergalactic gas and the interactions between galaxies and the surrounding gas, and 3) the nature and evolution of nascent galaxies. Collectively, these studies will provide a global picture of reionization.

To achieve these goals, our team is planning a dedicated galaxy survey with *JWST* in the sky regions towards known bright quasars with high-quality existing spectral data. The project will perform deep and wide slitless spectroscopy and imaging using the Near-InfraRed Camera (NIRCam), and will provide a sample of approximately 500 galaxies in and near the Epoch of Reionization. From these data, we will investigate the relation between galaxies and the intergalactic gas. The data collection will begin in around March of 2022, roughly half a year after the launch (which is expected in October of 2021).

The *JWST* data will be combined with our current and forthcoming complementary observations in these and additional quasar fields, thereby realizing a unique collaborative dataset. Specially, I am leading a ground-based galaxy survey with the Subaru Telescope, which is focused on exploring the origin of the opacity fluctuations. In the following, I introduce this project and present its first result.

CONSTRAINT OF REIONIZATION SCENARIOS BY SUBARU/HSC GALAXY SURVEYS

Figure 1 shows a real image of our observing program using the Hyper Suprime-Cam (HSC) mounted on the Subaru Telescope. Our program was designed to test competing models of the origin of large spatial variations in the Lyα optical depth of the intergalactic medium at the tail end of reionization. These models explain the observations by different "recipes", and predict different spatial correlations between the optical depth of the gas and the underlying number density of galaxies. Therefore, the models can be distinguished in principle by surveying galaxies along the lines of sight toward background quasars with the Lyα opacity information.

In the first quasar field, we have already associated a significant underdensity of galaxies to a region containing abundant amounts of residual neutral hydrogen (Kashino et al. 2020). Figure 3 shows the distribution of distant galaxies identified in our observations. This image is centered on a background quasar whose spectrum presents a remarkably large and opaque (i.e., high optical depth) absorption feature, where the galaxies are under-dense (the paucity of galaxies manifests as a dark hole at the image center). Our result is consistent with scenarios in which large opacity variations arise from enhanced fluctuations in the ultraviolet background radiation field or residual neutral islands, which remained until almost 2×10^8 years later than previously thought. Our program will observe six additional quasar fields, from which more conclusive statements will be drawn.

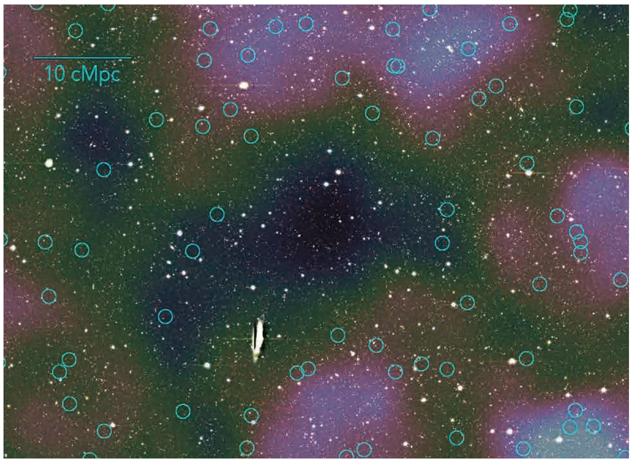

Figure 3. HSC sky image centered on the quasar J0148+0600. Shown are the distribution of target galaxies at the tail end of reionization (circles) and the surface density calculated from the number densities of those galaxies. The surface density (from low [dark] to high [bright]) was smoothed by a fixed aperture of 8 arcmin in radius.

Acknowledgements

The result presented here is based on data collected at the Subaru Telescope operated by the National Astronomical Observatory of Japan.

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[1]A quasar is an extremely luminous active galactic nucleus, in which a supermassive black hole is surrounded by a gaseous accretion disk.

[2]Astrophysicist refer all the chemical elements heavier than hydrogen and helium as heavy elements or "metals" .

Writing History in Late Antique Rome: A Study of Ammianus Marcellinus

Figure 1. Photograph of the author's bookshelf. The upper: Series of Japanese translations of Greek and Latin classics (Seiyo-koten-sosho). The lower: edited texts, commentaries, translations, and, modern researches relating to Ammianus Marcellinus and the late antique city of Rome.

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During so-called Late Antiquity (c. 250–700 CE) in European history, a variety of historical narratives were produced. They are important sources of information about the past but, given their diverse forms and subjects, their characteristics remain poorly understood. The purpose of this study is to elucidate the characteristics of Ammianus Marcellinus's historical narrative, the *Res Gestae,* by analyzing it within the political and social context of its composition in late fourth-century Rome. Based on the time and place at which it was written, my research seeks to reveal what Ammianus's contemporaries would have felt when reading his *Res Gestae*. To achieve this objective, this study compares the words of Ammianus with the results of current research in late antique studies, thus deciphering the meaning of his text and the historical significance of his work.

INTRODUCTION

Historiography is a useful source of information about the past, providing us not only with historical facts but also insight into belief and ideology. In this regard, European Late Antiquity is very interesting because in this period various kinds of historiography were produced from the interaction of Greek and Roman traditions with new elements, most notably Christianity.

Since the 1970s, historians have revealed various aspects of late antique societies. At first, they tended to use historiographical texts simply as depositories of information on historical events. Relatively little attention was given to inherent problems in the late antique historiographies themselves. However, scholars gradually noticed that these texts were not simple intermediaries of the past, but specific products reflecting a given author's attitudes and the political and social context. Recent scholarship has recognized that understanding the social background of each text leads to the expansion of our knowledge on Late Antiquity.

Nevertheless, because of its detailed and vivid descriptions of late Roman society and politics, Ammianus's work is regarded as one of the great Latin classics. Edward Gibbon, the author of *The History of the Decline and Fall of the Roman Empire,* a classical work of the eighteenth century, offered high praise of Ammianus: "an accurate and faithful guide, who has composed the history of his own times, without indulging the prejudices and passions, which usually affect the mind of a contemporary"[1]. Thereafter Ammianus was counted among the most significant historiographers by historians in modern times. *The Roman Empire of Ammianus* by J. Matthews [2] relies largely on Ammianus for historical information and has become the standard text on the later Roman Empire and its society.

Since the end of the last century, however, historians have given more attention to rhetorical technique. Doubting the credibility of Ammianus's words as a historical source, one historian even asserted that "his *Res Gestae* exhibit the creative and imaginative powers of a novelist" [3]. This opinion inspired subsequent researchers to investigate the text of Ammianus not in terms of historical accuracy but of literary method.

Although this approach has certainly achieved significant results, little consideration seems to have been given to the fact that Ammianus lived in the city of Rome. His texts must have reflected the political and social situation of late antique Rome.

THE CITY OF ROME IN LATE ANTIQUITY

Recent research has significantly improved our knowledge of late antique Rome. Over the last two decades researchers started to examine the city in Late Antiquity, especially the fourth century. In the historical narrative of the "decline of the Roman world," the city of Rome had been considered a symbol of downfall. Research on the city had remained undeveloped apart from a few works on the Christianization of Rome. However, the emergence of the concept of Late Antiquity in the 1970s encouraged new perspectives on the old capital of the empire. Researchers revisited historical sources including Ammianus. Combined with the rapid progress of archaeological research in Rome and the publication of a new edition of Latin and Greek inscriptions from the city, this has brought a wealth of fascinating data to our attention. We are now able to portray a lively, powerful image of society in late antique Rome, and possess adequate data to compare with the text of Ammianus.

RESEARCH FOCUS

In light of the research progress mentioned above, a new way to interpret Ammianus's historiography emerges. On reading his text, we sometimes find that the author omits information we might expect him to narrate. It is improbable that he had simply forgotten to mention it since, as recent research has shown, Ammianus carefully constructed his narrative. Furthermore, because he and his contemporary readers had a shared knowledge of Rome's history, they should have easily noticed intentional silences in the narrative. Therefore, an examination of why Ammianus preferred silence may help to unravel his hidden agenda.

SOURCES AND METHODS

The texts of Ammianus have been transmitted to us through manuscripts of the ninth century, which have been revised and published by classicists. The best known of these is Seyfarth's edition [4], which the present study largely relies upon. However, the accumulation of subsequent studies of Ammianus has identified occasional errors. With that in mind, I have strived to achieve a more accurate interpretation of the text.

For epigraphic texts, the emended and annotated collection of Latin inscriptions is useful. However, for the most recent excavations and revisions, it is necessary to review academic journals and research reports. Field surveys of relevant sites have been carried out to confirm the original location of inscriptions and their appearance. I have already surveyed twenty buildings in the city of Rome that are mentioned in the *Res Gestae*. Additional surveys are needed for sites in the Vatican and the suburbs of Rome.

To elucidate the meaning of Ammianus's narrative for his contemporaries in Rome, my study compares his texts with writings and inscriptions left by people mentioned in his work, and with the architecture and urban landscape of the time. In the process, I examine what is included in Ammianus's text and what is not. I determine whether it is intentional or unintentional through close reading of the narrative and rhetoric of the text itself. I then investigate the significance of what Ammianus wrote or did not write relative to the historical facts (political and social context) that were prerequisite knowledge among contemporary readers.

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Surviving in Seasonally Fluctuating Environments: How Animals Anticipate and Adapt

Japanese medaka (*Oryzias latipes*) with cherry blossoms, "sakura" in Japanese, one of the most famous symbols of spring in Japan.

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In most regions with a temperate climate, four seasons—spring, summer, autumn, and winter—cycle through the year. Since seasonal changes significantly affect environmental conditions, animals living in these regions need to anticipate and adapt to these seasonal changes. It has been known animals change their physiology and behavior between seasons to cope with environmental fluctuations. In addition, some seasonal activities are controlled by the endogenous annual clock, which are known as circannual clock, in some animals. However, the molecular mechanisms underlying seasonal adaptive strategies remain unclear. Japanese medaka (*Oryzias latipes*) (Top picture) is a good model to study seasonal adaptation because of its clear seasonality and suitability for molecular analysis. Using this model, we recently demonstrated the molecular basis of seasonal changes in color perception and stress response behavior. We are now trying to understand the molecular mechanisms of circannual clock using this small fish.

INTRODUCTION

When you look out over the world, you will notice there are regions with different climates. Although these regions have different environmental conditions, animals and plants have evolved and adapted to each condition. For example, the polar region or the desert environment is far too harsh for most organisms due to their extreme temperature and food scarcity; some organisms can still survive in these environments. On the other hand, in a temperate climate zone, whose environmental conditions are moderate compared to these harsh regions, dynamic fluctuations occur during seasonal changes (Fig. 1). Since the environmental fluctuations repeat every year, animals living in temperate regions need to predict and prepare for the next season. But how do organisms living in these regions anticipate and adapt to impending environmental variations?

SURVIVAL STRATEGIES IN THE TEMPERATE ZONE

Animals undergo seasonal alterations in physiology and behavior to cope with the dynamic environmental changes. For example, there are seasonal changes in animal reproduction, growth, metabolism, immune function, and hibernation. Although the mechanism regulating seasonal reproduction has been uncovered recently (1), the molecular mechanisms underlying other seasonal activities remain unelucidated.

JAPANESE MEDAKA IS A GOOD MODEL TO STUDY SEASONAL ADAPTATION

Investigations using mice, Drosophila, and zebrafish have made significant contributions to life science research for many years. However, these animals lack seasonality because they originate in regional environments with little seasonal variation. Therefore, we have chosen a small fish, Japanese medaka (*Oryzias latipes*), as a model for studying seasonal adaptation because of its highly sophisticated seasonal responses, availability of genomic information, and compatibility with the existing genome editing tools.

SEASONAL CHANGES IN COLOR PERCEPTION

Medaka alter their behavior between seasons. In winter, medaka are less active and stop breeding. However, from spring to summer, they become very active and breed almost every day. Also, we found that medaka showed seasonal changes in light sensitivity. Because medakas' body color becomes brilliant in a show of nuptial coloration during the breeding season, we hypothesized that the perception of nuptial coloration also varies between seasons. We used virtual fish created with computer graphics to test medakas' preference. Only summer medaka exhibited a preference for the virtual fish with nuptial coloration, suggesting their color perception undergoes seasonal changes. Although the changes in photosensitivity have been reported in some other species, their physiological and ecological significance had not been elucidated.

We utilized genome-wide expression analysis and genome editing techniques to study these molecular mechanisms and their functional significance. By studying the change in the genome-wide gene expression in the eye of medaka from winter to summer, we identified many genes involved in the phototransduction were induced in summer. Genome edited medaka lacking the photopigment gene showed a reduced light sensitivity and a weaker preference for virtual fish with nuptial coloration under summer conditions. These results suggest that plasticity in color perception is crucial for the emergence of seasonally regulated behaviors (2).

LONG NON-CODING RNA, *LDAIR,* REGULATES STRESS RESPONSE BEHAVIOR

During the breeding season, animals need to increase their activity to find their mating partners and produce offspring. Although these behavioral changes are advantageous to breeding, they simultaneously expose the animal to environmental dangers, such as predation, interspecific competition, and intraspecific competition. As a result, many animals undergo stress responses, such as self-protective and escape behavior, to decrease these risks during the breeding season (3). However, the molecular basis of seasonal changes in stress response remains to be understood. By genome-wide expression analysis of the brain, we found that uncharacterized long non-coding RNA (lncRNA), *LDAIR*, is strongly induced by the long-day stimulus, which mimics the breeding season. We next performed a genome-wide expression analysis of the genome edited, *LDAIR* knockout fish to uncover the *LDAIR*'s function. We found that the *LDAIR* locus regulates the *corticotropin-releasing hormone receptor 2* (*CRHR2*), one of the genes involved in stress response. The behavioral analysis of *LDAIR* knockout fish revealed that *LDAIR* affected the fish's self-protective behaviors under long-day conditions. Therefore, we propose that the photoperiodic regulation of CRHR2 by *LDAIR* modulates adaptive behaviors to seasonal environmental changes (4). Interestingly, while most of lncRNAs' functions are still unknown, it has been reported that lncRNAs exist in similar numbers to protein in mammals. Because lncRNAs are involved in seasonal adaptation in plants, we propose that lncRNAs may also regulate environmental adaptation in animals.

INTERNAL CLOCK FOR ADAPTING TO THE ANNUAL SEASONAL CYCLE

Organisms living on earth experience two fundamental periodicities, daily and annual, generated according to the earth's rotation and orbit. Organisms have evolved internal biological clocks, i.e., the circadian clock and circannual clock, to anticipate these cyclical changes. The circadian clock generates a 24 -hour rhythmicity in many biological processes for adapting to day-night cycles. The molecular mechanisms controlling the circadian rhythm remained unknown until the early 1980s. Since then, three American scientists have discovered this mechanism and received the Nobel Prize in Physiology or Medicine for their work in 2017. The circannual clock drives annual rhythmicity in several biological activities for the adaptation to seasonal cycles. Pengelley and Fisher first demonstrated ground squirrels show endogenous annual rhythmicity in body weight, food consumption, and hibernation in the mid-twentieth century (5). Since then, many other organisms have been reported to show circannual rhythm in seasonal activities, such as reproduction, growth, and hibernation. However, the molecular mechanism of circannual rhythms is still an enigma. In our previous study, we found that medaka exhibited annual rhythmicity in reproduction. A genome-expression analysis of time-series samples from different seasons revealed several thousand transcripts that exhibited an annual oscillation. Currently, we are investigating how these genes generate annual rhythmicity.

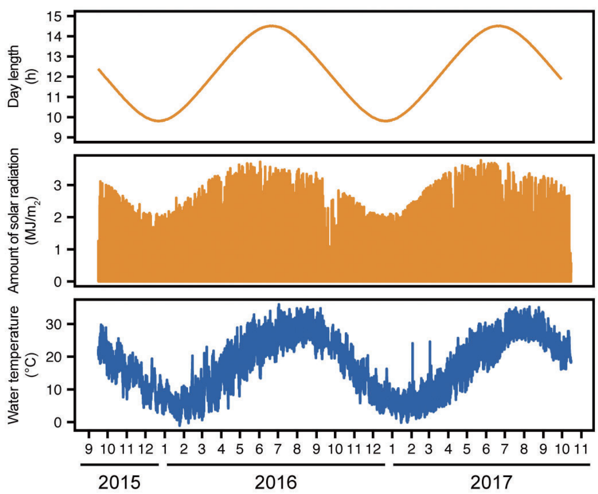

Figure 1. Seasonal variations in day length, amount of solar radiation and water temperature (Unpublished data).

Acknowledgements

I would like to express my sincere appreciation of Prof. Takashi Yoshimura for his continual support for my research and comments on the manuscript.

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Central Visual System of Fish – How do Fish Look at the World? –

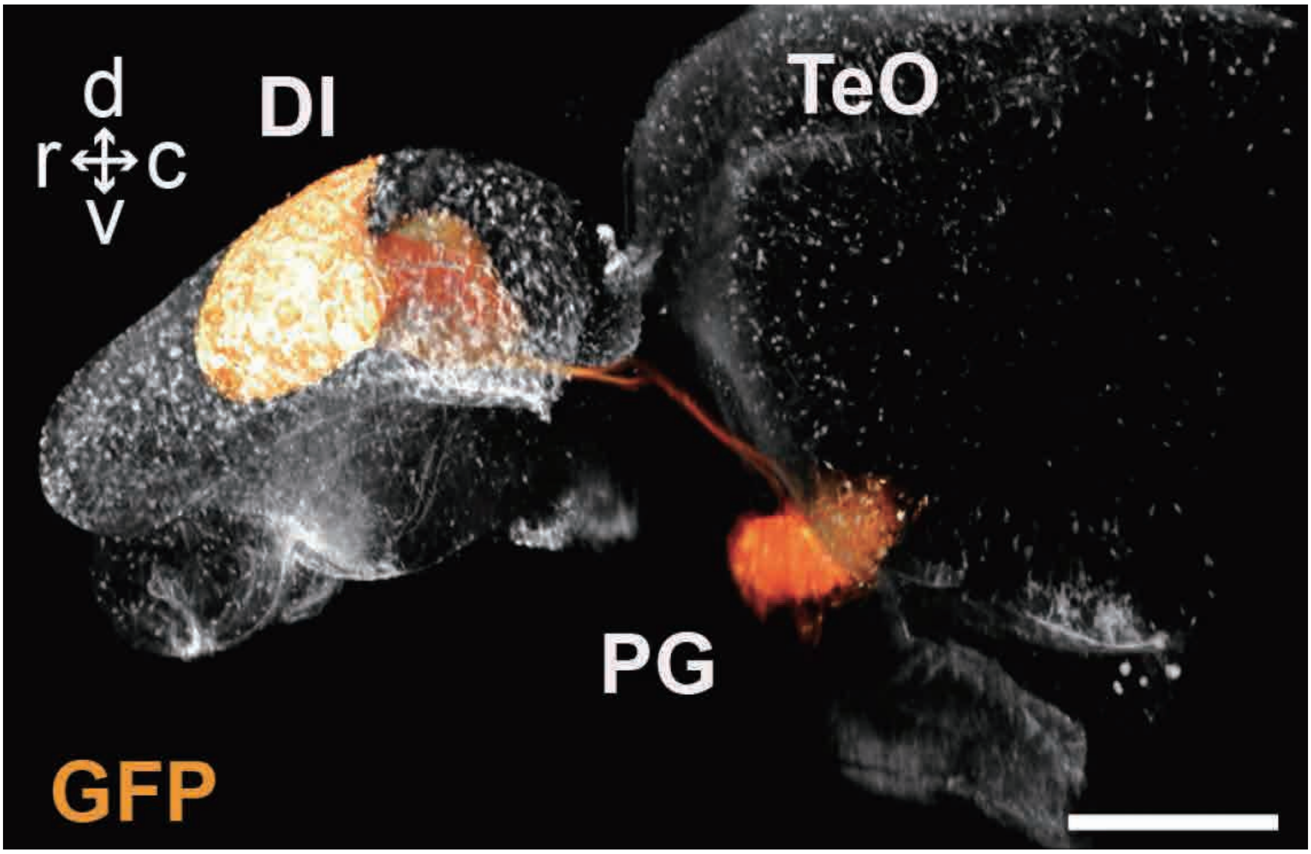
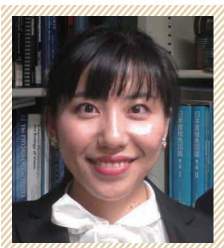


Figure 1. The brain of a transgenic zebrafish in which green fluorescent protein (GFP) is expressed in neurons of the visual relay nucleus (a nucleus of preglomerular complex [PG]) in the diencephalon. GFP-positive neurons extend axons to the telencephalon (especially to the lateral part of dorsal telencephalic area [Dl]). TeO, optic tectum. Orientation: r, rostral; c, caudal; d, dorsal; v, ventral. Scale bar = 500 μm. [From Bloch & Hagio et al., 2020, eLife]



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Two ascending visual pathways to the telencephalon are present in most vertebrates. However, some species of fish possess only one visual pathway, although others have two. Our studies suggest that the common ancestor of actinopterygians possessed two pathways, and later, one of them was lost in the common ancestor of acanthopterygians, which includes most species for fisheries. We also found that the visual pathway in goby fish has a topographic organization. Furthermore, we investigated a gene specifically expressed in the diencephalic visual relay nucleus. In the future, we aim to elucidate functions of visual pathways using genome editing and microscopic live imaging analyses on visually-evoked neural activities.

INTRODUCTION

Most vertebrates, including fish, recognize food and predators for survival as well as individuals of the opposite sex for reproduction using sensory systems. The visual sensory system is especially important for many vertebrate species. While it has been recognized that elucidation of vision in fish is extremely important in the academic field as well as the fisheries industry, the visual system of fish is poorly understood with only fragmental studies available. To understand vision of fish, revealing the visual pathways from the retina to the telencephalon is a necessary first step.

Mammals possess two ascending visual pathways from the retina to the telencephalon (pallium/cerebral cortex). One of the two visual pathways in mammals is called the geniculate system in which retinal input is sent to the primary visual cortex after relay in the lateral geniculate nucleus in the diencephalon. The other pathway is called the extrageniculate system, where retinofugal information reaches the higher-order visual cortex via the superior colliculus in the mesencephalon and then the lateral posterior nucleus-pulvinar complex in the diencephalon. Similarly, two visual pathways are present in birds, reptiles, amphibians, and cartilaginous fishes. Two visual pathways also appear to be present in bichirs and sturgeons, which are non-teleosts and represent early branches of actinopterygian radiation. In teleosts, the goldfish and carp possess two visual pathways to the telencephalon; however, the squirrelfish, which is an acanthopterygian fish, possesses only one visual pathway or extrageniculate-like pathway.

EVOLUTION OF THE VISUAL PATHWAYS IN FISH

Knowledge on the visual pathways in fish is limited only to a handful of species, despite the diversity of fishes, with more than 30,000 species. Therefore, we investigated visual pathways in the yellowfin goby, *Acanthogobius flavimanus,* that appeared later than squirrelfish. We revealed that the yellowfin goby possesses only an extrageniculate-like pathway in which retinal inputs reach the dorsal telencephalon via the optic tectum in the mesencephalon and then the nucleus prethalamicus (PTh) in the diencephalon [1, 2]. Our studies suggest that the common ancestor of actinopterygians possessed two pathways, and later, the geniculate-like pathway was lost in the common ancestor of acanthopterygians, which includes many species for fisheries (Figure 2). We continue studies on the visual pathways in several fish species.

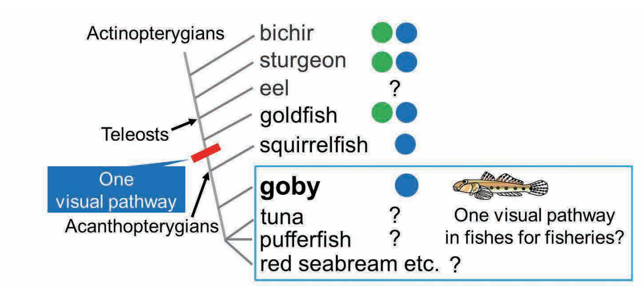

Figure 2. Evolution of the visual pathways from the retina to the telencephalon in fish (green circle: geniculate-like pathway; blue circle: extrageniculate-like pathway).

VISUAL RELAY NUCLEUS IN DIENCEPHALON OF FISH

We also found that the PTh of yellowfin goby or the visual relay nucleus in the diencephalon is composed of two subnuclei (medial and lateral: PTh-m and PTh-l, respectively) [3]. It is known that retinal projections to the optic tectum are organized topographically; however, studies on the possible topographic projections of the tectum to the diencephalic visual relay nucleus remained to be studied. We injected neural tracers into different tectal regions. Our study revealed that the medial tectum projects to the PTh-m and a ventromedial zone of PTh-l, and the lateral tectum projects only to a dorsolateral zone of PTh-l. Therefore, the mediolateral axis of the tectum is directly projected upon the mediolateral axis of PTh-l, suggesting the topographical organization of tecto-prethalamic projections, as in mammals (Figure 3).

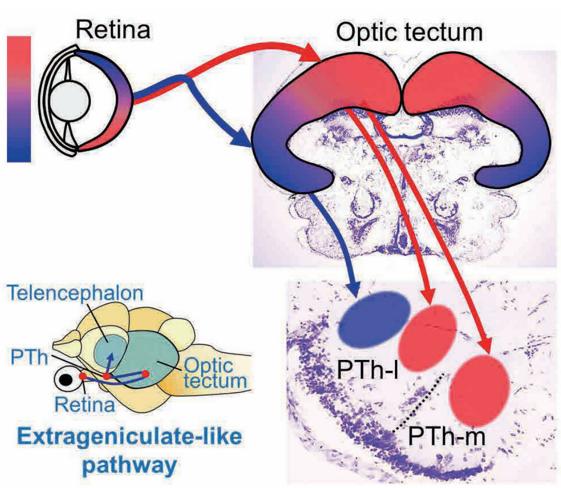

Figure 3. Topographic organization of the retino-tecto-prethalamic pathway (red: Information from the dorsal visual filed; blue: Information from the ventral visual field) and a schematic illustration of the extrageniculate-like pathway in yellowfin goby from the retina to the telencephalon (bottom left).

AIMING AT HIGHER VISUAL FUNCTIONS IN FISH

Larvae of the zebrafish are used as a model for fluorescence imaging studies to visualize neuronal activities. Many neuroscientists observed real-time neuronal activities in the optic tectum by visual stimulation using fluorescent Ca^{2+} indicator and DNA-encoded Ca^{2+} indicators, such as GCaMPs. Although visual information reaches the diencephalon mediated by the optic tectum, much information is lacking regarding the neuronal activities in the diencephalic nucleus, since the knowledge on the diencephalic visual center in zebrafish remains undetermined. Therefore, we have identified the visual relay nucleus in the diencephalon, which receives projections of the optic tectum and sends axons to the telencephalon. We searched for transgenic zebrafish in which green fluorescent protein (GFP) is expressed in neurons of the visual relay nucleus and identified a gene specifically expressed in the nucleus (Figure 1) [4]. Thus, analyses on visually-evoked neuronal activities may be possible in the diencephalic relay nucleus, a higher-order visual center than the optic tectum, using Ca^{2+} indicators.

It is necessary to investigate the telencephalic visual circuits and processing of visual information that reaches the telencephalon. We constructed an atlas of the telencephalon based on cytoarchitecture, neurochemical markers, and gene expressions in *Rhinogobius flumineus* [5]. We are in the process of obtaining data regarding intratelencephalic connections in some species of teleosts, and in the future, we aim to elucidate functions using transgenic fish and imaging analyses on visually-evoked neural activities.

We have collaborated with other neuroscientists to understand functional systems other than vision, such as the spinal cord and the cerebellum [6, 7]. We are collaborating with several researchers in Japan and Norway for the advancement of research and education for aquaculture. In the future, we would like to identify attractive visual stimuli for fishes and utilize their characteristics for the improvement of fishing gear and the like, to contribute not only to the academic field but also to the fisheries industry.

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Archival Explorations of Extreme Solar Eruptions in the Past

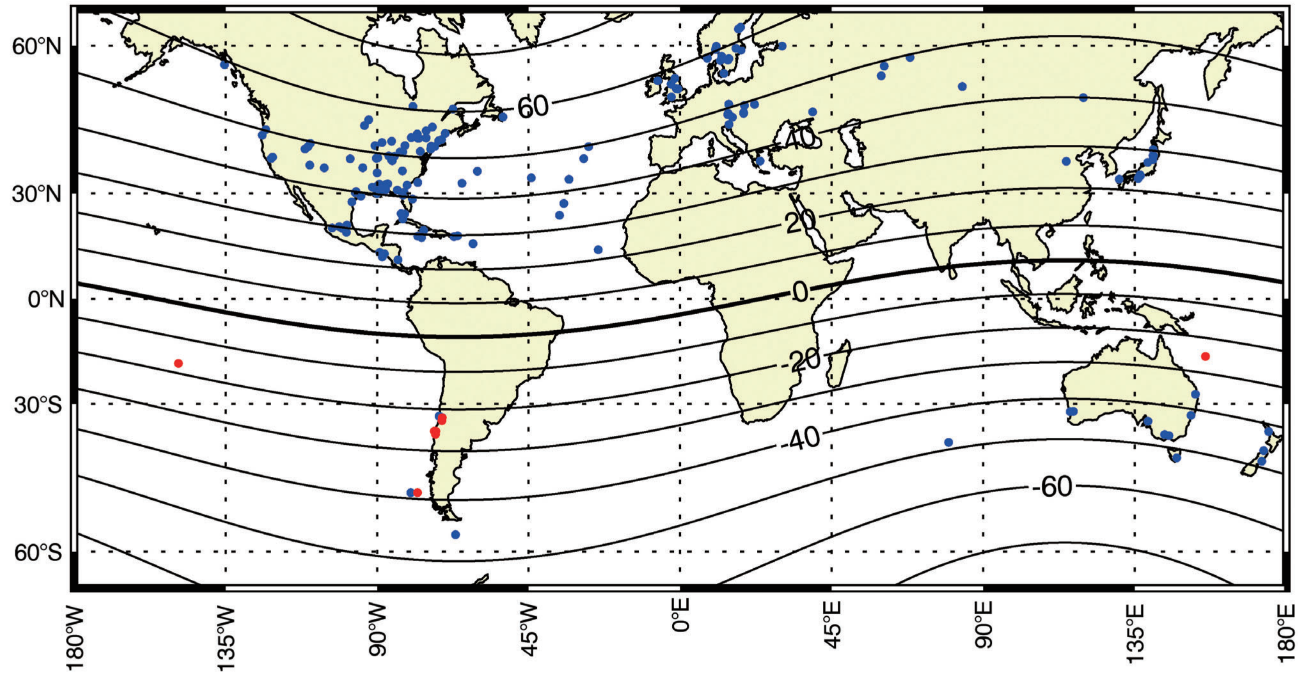

Figure 1. Reconstructed auroral visibility during the Carrington storm in 1859. The blue dots had been already known by the date of Hayakawa et al. (2019) and the red dots have been added in Hayakawa *et al.* (2020c).

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Hisashi Hayakawa analyzes past solar eruptions and their terrestrial impacts using contemporary analog records. He analyzes sequences ranging from solar flares to geomagnetic storms in the analog records of past solar observations, geomagnetic measurements, and auroral sightings, quantitatively scaling their intensities and reconstructing their time series. The existing databases of extreme solar flares and geomagnetic storms can then be chronologically extended for centuries from less than one century to several centuries. By analyzing historical chronicles and diaries, Hayakawa and his colleagues hope to further extend our existing databases to millennial time scales for comparison with proxy data from natural archives. Based on historical observations of sunspots and solar coronae, he intends to quantitatively improve and reconstruct long-term solar variabilities such as the Maunder Minimum and the Dalton Minimum. As such, they are contextualizing modern solar storms and solar variability to longer time scales for comparisons with extreme cases.

INTRODUCTION

Although the Sun supports all terrestrial life, it occasionally erupts, flooding the near-Earth space environments with plasmas, radiations, and particles. Solar flares from significant sunspots typically launch interplanetary coronal mass ejections (ICMEs). When sufficiently geo-effective, these ICMEs cause geomagnetic storms in the terrestrial magnetic field and extend the auroral oval equatorward. With its increasing dependence on technology-based infrastructures, modern civilization is becoming increasingly vulnerable to disruptive solar eruptions. In March 1989, the greatest geomagnetic storm in the space age caused serious blackouts in Quebec, along with significant economic impacts (Riley *et al.,* 2018). The most intense geomagnetic storm ever recorded often is considered as the "Carrington storm" in September of 1859 (with a maximum -Dst of ~900 nT), which caused extreme geomagnetic disturbance even in India, and auroral observations down to the Caribbean coasts (Cliver and Dietrich, 2013). In modern analyses, the consequence of this event was estimated as catastrophic and the aftermath was diminished only after years of recovery (Baker et al., 2008). Therefore, understanding these hazards is necessary for mitigating their potential economic and social impacts in future.

Fortunately or unfortunately, such superstorms are fairly rare. The Dst index, which evaluates the intensity of mid-latitude geomagnetic disturbances, has captured only one superstorm (the March 1989 event) during its chronological coverage since 1957 (Riley *et al.,* 2018). Bridging the gap between the existing indices and the historical superstorm records (including the September 1859 event) is of significant interest.

INVESTIGATIONS OF HISTORICAL ARCHIVES

To understand historical storms before the space age, we must consult analog observational records of those events, which are sometimes published in yearbooks, journals, and other scientific publications. Additional records are preserved in the archives of major observatories and libraries. Records in non-scientific documents such as diaries and chronicles should also be consulted, especially in qualitative narratives. Based on these records, we can reconstruct the time series of solar eruptions (solar flares) and terrestrial impacts (geomagnetic storms and low-latitude aurorae). The equatorial boundary of the auroral oval is known to be empirically correlated with the intensity of a geomagnetic storm.

UNDERSTANDING THE CARRINGTON STORM

We first analyzed the terrestrial impacts of the Carrington storm, a benchmark of severe space-weather events. We know that aurorae triggered by this event were observed at the Caribbean coasts, but the extant investigations are geographically concentrated in North America and Western Europe. Therefore, we extended our surveys to East Asia, Russia, Ireland, and Iberia in the Northern Hemisphere (Hayakawa *et al.,* 2019), and to South America and Oceania in the Southern Hemisphere (Hayakawa *et al.,* 2020c). Through our investigations, the equatorial boundary of the auroral oval was updated to an invariant latitude (ILAT) of ~|25.1|° (Hayakawa *et al.,* 2020c).

COMPARISON WITH OTHER SUPERSTORMS

The Carrington storm was not likely unique. We examined the auroral records of the great storms in February 1872 and May 1921, and reconstructed their equatorial boundaries. The auroral ovals in the 1872 and 1921 events were found at |24.2|° and |27.1|° ILAT, respectively (Hayakawa *et al.,* 2018, 2019). These equatorial auroral extensions well agreed with that of the Carrington storm (Hayakawa *et al.,* 2019), and with reconstructions of the geomagnetic measurements, in which the intensity of the May 1921 storm was maximized at –Dst = 907 ± 132 nT (Love *et al.,* 2019).

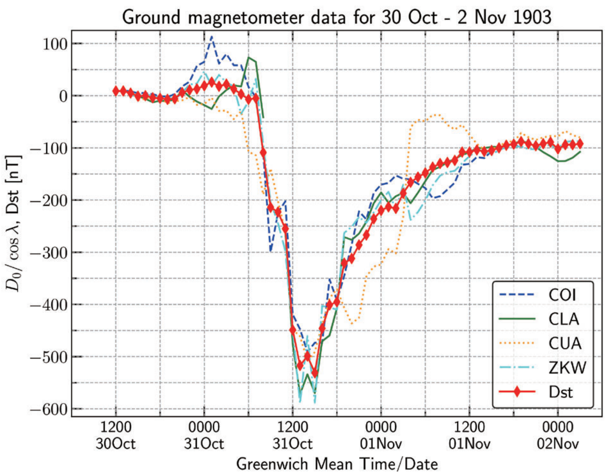

Figure 2: Reconstructions of the historical superstorm in October/November of 1903 (Hayakawa *et al.,* 2020a)

RECONSTRUCTIONS OF HISTORICAL SUPERSTORMS

The above reconstructions were extended to other historical superstorms. Thus far, we have identified at least seven superstorms post-1850, occurring on September 1859, February 1872, October/November 1903, September 1909, May 1921, March 1946, and March 1989. Especially, the October/November superstorm in 1903 occurred just after the minimum of a weak solar cycle (SC14). After investigating four historical magnetograms, we reconstructed the maximum intensity of this event as -Dst ~ 531 nT (Figure 2). This intensity was slightly below that of the most extreme geomagnetic storm in the space age, but far exceeded the second-most extreme storm in the space age. Moreover, this case report warns us that geomagnetic superstorms can occur even near the minima of weak solar cycles (Hayakawa *et al.,* 2020a). We further analyzed the sequence of extreme solar flares and extreme geomagnetic storms in March 1946. We located evidence of an intense solar flare at the Tashkent Observatory in Uzbekistan (see Figure 3). Based on four mid-latitude magnetograms, we reconstructed the maximum intensity of the resultant geomagnetic storm as -Dst > 512 nT.

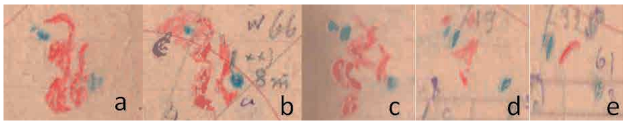

Figure 3: Time series of an intense solar flare recorded at Tashkent Observatory (Hayakawa et al., 2020b), courtesy of Ulugh Beg Astronomical Institute (UBAI) of the Uzbekistan Academy of Sciences.

SUMMARY AND FUTURE WORKS

We have reconstructed the historical time series of intense solar eruptions and geomagnetic superstorms. However, several storms have not been quantitatively examined. Applying the above analyses to these events would chronologically extend the intensity estimates of historical storms. Moreover, our analyses are potentially extendible to the period beyond the onset of the regular geomagnetic measurements began in the 1840s, using auroral records as the primary references.

Acknowledgements

Hisashi Hayakawa thanks all his collaborators for fruitful discussions and valuable contributions to the above analyses. He also thanks the Ulugh Beg Astronomical Institute (UBAI) of the Uzbekistan Academy of Sciences for kindly permitting use of the Tashkent flare observations.

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Evolution of Bioluminescence in the Ocean

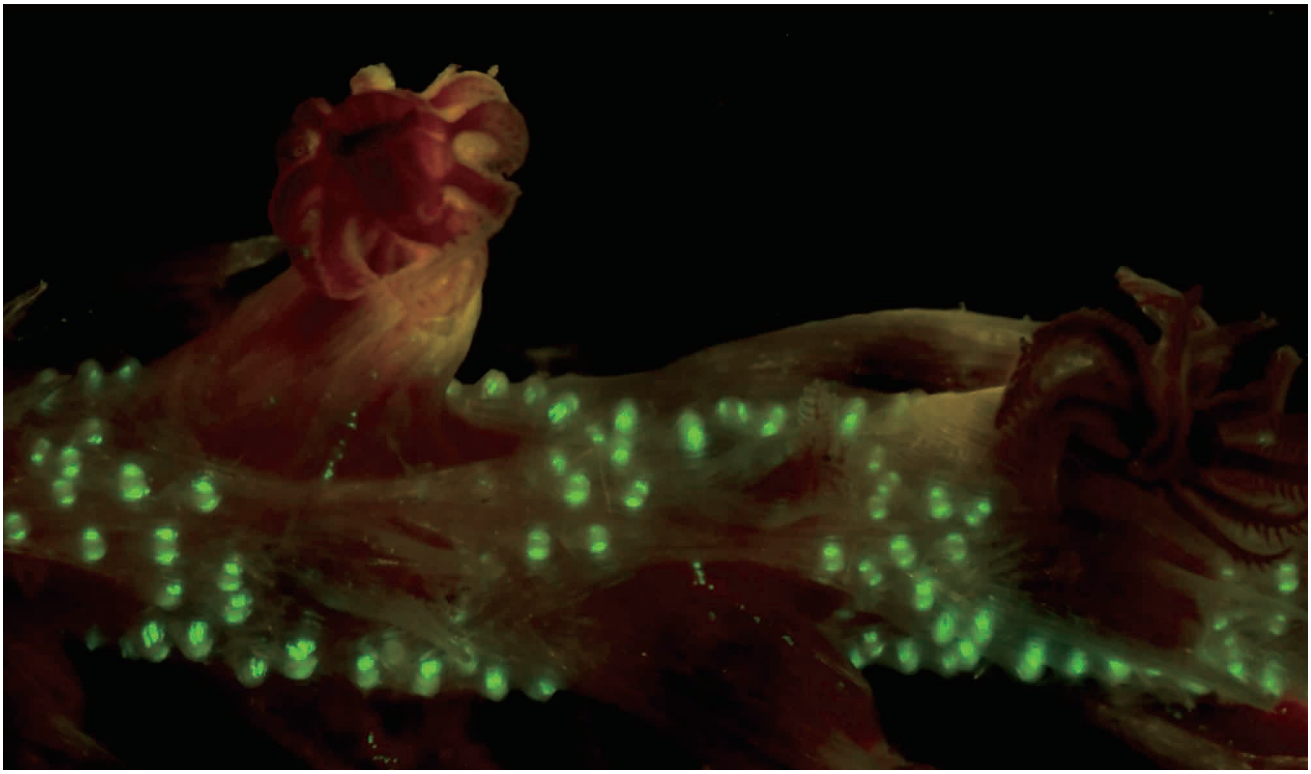
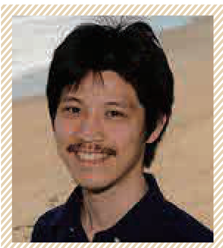


Figure 1. Deep-sea coral *Funiculina* sp. collected at 1,000 m below sea level emits green light. Under natural conditions, blue bioluminescence is generated by coelenterazine and luciferase and is then converted to green by the green fluorescent protein.



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Bioluminescence is one of the most common characteristics of living organisms on the planet, especially considering that most animals that inhabit the ocean are luminous. Although it is estimated that bioluminescence evolved independently more than 80 times across the tree of life, only a handful of luminous animals have been chemically studied. Poor knowledge concerning its molecular mechanisms limits our understanding of the evolution of bioluminescence. To understand bioluminescence evolution, I studied the biochemical mechanism of the light-producing reaction in unexplored animal groups, such as fishes, corals, and many other deep-sea animals. In this article, I introduce my research by focusing on two recent works on the origin of bioluminescence in deep-sea corals and kleptoprotein bioluminescence in fish.

EARTH IS FULL OF BIOLUMINESCENCE

Bioluminescence is light produced by a biochemical reaction in a living organism. On land, only a couple of animals are bioluminescent (e.g., fireflies and luminous mushrooms), but in the ocean, the majority of animals from the surface down to the ocean floor can emit light. Luminous organisms are found across a variety of taxa such as bacteria, Ctenophora (comb jelly), Cnidaria (jellyfish and coral), Arthropoda (shrimp and krill), and Vertebrata (tunicate and fish). A video camera observation using a submarine found that 76% of macroscopic animals are luminous [1]. This number represents the ecological significance of bioluminescence in the ocean, indicating that natural selection prefers bioluminescence evolution. In fact, a recent study reported that bioluminescence evolved independently more than 80 times [2].

The bioluminescent reaction is the oxidation of the luciferin molecule catalyzed by luciferase protein with or without cofactors. The independent evolution of bioluminescence resulted in several unique luciferins and luciferases. Animals that have different evolutionary origins have different luciferin and luciferase structures. A comparison of the chemistry of bioluminescence provides a clue to its evolution. However, the biochemistry of bioluminescence has only been studied in a handful of animal groups. Here, I introduce my recent studies: a natural history of luminous anthozoans; and a bioluminescent fish stealing luciferase from its ostracod prey.

ANCIENT GLOW IN THE DEEP-SEA

Class Anthozoa, composed of hard and soft corals, sea anemones, and sea pens, is a large group containing approximately 7,500 species belonging to the phylum Cnidaria. Luminous species are taxonomically sparsely reported from 2 families in subclass Hexacorallia and 15 families in subclass Octocorallia. The distant relationship of several luminous groups in Anthozoa indicated multiple origins of bioluminescence. However, a poorly resolved Anthozoa phylogeny limits our understanding of bioluminescence evolution.

Most of the previous studies on luminous anthozoans were descriptive, lacked chemical analyses, and mainly focused on shallow-water species. The sea pansy *Renilla reniformes* (Renillidae, Pennatulacea, Octocorallia) is the only well-studied luminous anthozoan. *Renilla* emits blue light upon stimuli using coelenterazine (luciferin), *Renilla* luciferase, and oxygen without cofactors. Coelenterazine is a common luciferin among marine luminous organisms, and *Renilla* luciferase is similar to bacterial hydrolase but is not comparable to any other known luciferases. Thus, revealing the origin of *Renilla*-type luciferase would lead to the elucidation of bioluminescence origin in Anthozoa.

As a part of the Monterey Bay Aquarium Research Institute (MBARI) project lead by senior scientist Dr. Steven Haddock, I explored the deep-sea floor of Monterey Bay using a remotely operated vehicle (ROV). A super high-sensitivity camera mounted on the ROV enabled me to test the bioluminescence of deep-sea corals at 4,000m below sea level. During the expedition, I discovered that one hexacoral sea anemone and three octocorals were luminous; these organisms are the first reported luminous specimens in their respective families. Chemical analysis showed that their molecular mechanisms were similar. Coelenterazine and coelenterazine-dependent luciferases were detected in all of the anthozoans. Western blotting analysis using the anti-*Renilla* luciferase antibody suggested the homology of luciferase among all the luminous octocorals tested. This result suggests that all the luminous octocorals inherited light production abilities from a common ancestor in the Silurian era [3]. Imagine the night ocean ~450 million years ago, there are many ancient corals in front of you. A coral you touch suddenly emits green light (Figure 1). Another coral displays a blue light wave propagating from the point you pinched. This might just be a dream, or reality in the ancient deep-sea environment.

Out of 3,000 species in Octocorallia, why are only a few dozen octocorals known to be luminous? This study suggests that there are perhaps hundreds or even thousands of octocorals that could be luminous species. Just as trees in a forest that provide structural complexity to harbor biodiversity, corals make up the base of the ecosystem that supports biodiversity in the ocean. Although the ecological role of bioluminescence in corals is not understood, bioluminescence certainly has some function as a signal for communication with other animals. Human activities, such as deep-sea mining to collect rare metals, have resulted in the resuspension of sediments over the years, ruining bioluminescent communication and likely destroying ocean biodiversity.

LUMINOUS FISH

Fish are a diverse group and have evolved various ways to produce and use light. Anglerfish and flashlight fish are popular fishes that rely on symbiotic bacteria for their luminescence. On the other hand, other fishes emit light without the aid of symbionts. Interestingly, some fishes use luciferin molecules, which is identical to other luminous creatures. For example, the ostracod *Cypridina noctiluca*, a sesame seed-sized crustacean, uses vargulin as its luciferin. Vargulin has been detected in some luminous fishes such as a sweeper *Parapriacanthus*, a cardinal fish *Jaydia*, and a midshipman fish *Porichthys* (three fishes belonging to different families!). Scientists thought the fishes could obtain small luciferin molecules by eating ostracods, similar to us obtaining vitamins from fruits, and could produce light using its own luciferase. Although there are more than 800 species of luminous fishes that do not rely on symbionts for their luminescence, no luciferase has been identified, limiting our understanding of bioluminescence evolution in fish.

In the course of identifying the luciferase enzyme in fish in my research, I found a surprising phenomenon that has never been reported in any organism before [4].

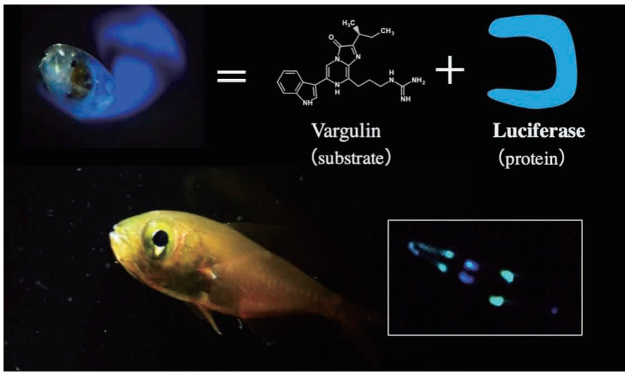

Figure 2. Luminous ostracods produce light using vargulin and luciferase. *Parapriacanthus ransonneti* prey on ostracods and sequester both vargulin and luciferase protein for light emission. (inset) Ventral view of *P. ransonneti* bioluminescence.

KLEPTOPROTEIN BIOLUMINESCENCE

The golden sweeper *Parapriacanthus ransonneti* is a nocturnal coastal fish that has two light organs (thoracic and anal) connected to the digestive tract. A previous study showed that *Parapriacanthus* uses vargulin as luciferin, but the luciferase protein and its encoding gene were unknown. To reveal the luciferase of *Parapriacanthus*, I purified the luciferase protein from the light organ using chromatography techniques based on luminescent activity. The isolated fish luciferase was identical to the luciferase of the luminous ostracod *Cypridina noctiluca* (Figure 2). The existence of *Cypridina* luciferase was further confirmed by western blotting and observations with immunohistochemistry using the anti-*Cypridina* luciferase antibody. This finding was unexpected because ingested proteins are generally digested and broken into small peptide fragments and amino acid molecules, which retain no original enzymatic activity. However, the luciferase protein in *Cypridina* retained the structure and light-producing activity in the specific cells of the *Parapriacanthus* light organs, which are located after the stomach and digestive tract.

Stealing protein from prey is new to science and is also a novel process of evolving a trait that already exists in another organism. This trait resembles kleptoplasty, one example of which Sacoglossa sea slugs sequestering chloroplasts of algal prey for photosynthesis, and kleptocnidism, examples of which nudibranchs, comb jellies, and flatworms sequestering stinging cells of cnidarian jellyfish or corals for defensive use. We named the protein sequestering found in the fish 'kleptoprotein' after those intriguing phenomena. Unlike kleptoplastids and kleptocnidids, scientists have overlooked kleptoproteins because exogenous proteins cannot be distinguished by microscopic observation. Recent advancements in mass spectrometry technology and multi-omics research may lead the discovery of more kleptoproteins, allowing for further elucidation of the complex connectivity of our lives in the Earth's diverse ecosystem.

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Non-Holomorphic Modular Forms and Modular Knots

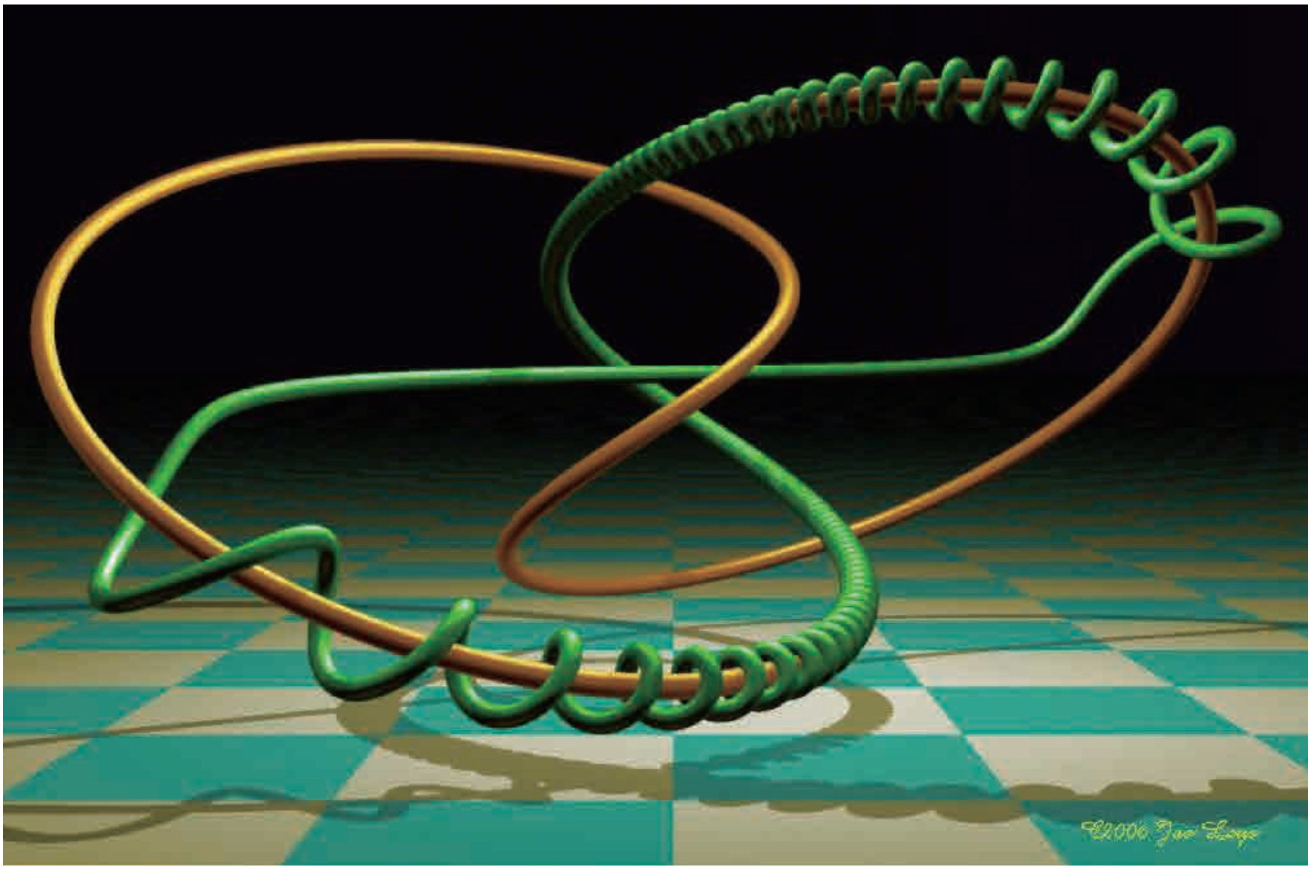

Figure 1: The modular knot associated to a hyperbolic $\gamma = \begin{pmatrix} 5 & 2 \\ 747 & 299 \end{pmatrix}$ in the homogeneous space $SL_2(\mathbb{Z}) \backslash SL_2(\mathbb{R})$. [4] Jos Leys.

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Modular forms are vital objects in classical and modern mathematics. This theory plays a crucial role as a bridge between number theory, topology, harmonic analysis, arithmetic geometry, combinatorics, representation theory, mathematical physics, etc. My research interest is investigating the roles of its generalization called "non - holomorphic modular forms" in this wide range of fields. In particular, I have been working on it from the viewpoints of number theory and knot theory.

IN MATHEMATICS, the act of counting something has been a fundamental problem since ancient times. It has been solved using the theory of modular forms. We begin by giving an exciting connection between partitions and modular forms to let the readers know the modular forms' charm. A partition function $p(n)$ is a classical arithmetic function, which counts the number of all partitions of a positive integer n. For example, the partitions of $n = 3$ and $n = 4$ are

$$3 = 2 + 1 = 1 + 1 + 1,$$
$$4 = 3 + 1 = 2 + 2 = 2 + 1 + 1 = 1 + 1 + 1 + 1,$$

and so $p(3) = 3$ and $p(4) = 5$. We can easily obtain $p(1) = 1, p(2) = 2, p(5) = 7$, and so on. Then, can we count the number $p(n)$ for a given large number n? For instance, what is $p(200)$? One hundred years ago, MacMahon computed the value $p(200) = 3{,}972{,}999{,}029{,}388$. Of course, he did not count them one by one, but he used a special function called a modular form. Let us now consider the infinite product

$$\prod_{n=1}^{\infty} \frac{1}{1-q^n} = (1 + q + q^2 + \cdots)(1 + q^2 + q^4 + \cdots)(1 + q^3 + q^6 + \cdots)\cdots$$

and expand brackets as = $1 + q + 2q^2 + 3q^3 + 5q^4 + 7q^5 + \cdots$. We then observe that the coefficient of q^4 corresponds to the number of partitions $p(4) = 5$. All partition functions are obtained by a relatively simple (one-line) sum-product formula

$$\sum_{n=0}^{\infty} p(n) q^n = \prod_{n=1}^{\infty} \frac{1}{1-q^n} = \left(\sum_{n=-\infty}^{\infty} (-1)^n q^{\frac{3n^2+n}{2}} \right)^{-1}$$

What is this infinite product? Let $P(q)$ denote the product. In harmonic analysis, the function $P(q)$ is characterized by the Cauchy-Riemann differential equation and a certain symmetry, that is, $P(q)$ is a (holomorphic) modular form. In this example, the arithmetic question "Compute the value $p(200)$" is solved using the modular form $P(q)$.

HARMONIC MAASS FORMS are "non-holomorphic" generalization of classical modular forms. The theory of harmonic Maass forms has been studied extensively since the discovery by Zwegers in 2002. The function is also characterized by the same symmetry and another differential equation. Though this new theory is generally more complicated than the classical one, it also has quite rich applications in number theory, topology, and mathematical physics. In my previous works [5, 6], I introduced a far broader generalization named "polyharmonic weak Maass forms," and investigated them from the viewpoint of number theory.

IN THIS ARTICLE, we introduce my recent work [7] on a relation between non-holomorphic modular forms and modular knots in topology. At the 2006 International Congress of Mathematicians, Ghys [2] presented a talk titled "Knots and dynamics," and asserted that "Isotopy classes of Lorenz knots and modular knots coincide." A knot is a loop made by connecting both ends of one piece of string in 3-dimensional space. Thus, a Lorenz knot is a periodic orbit appearing in the Lorenz attractor.

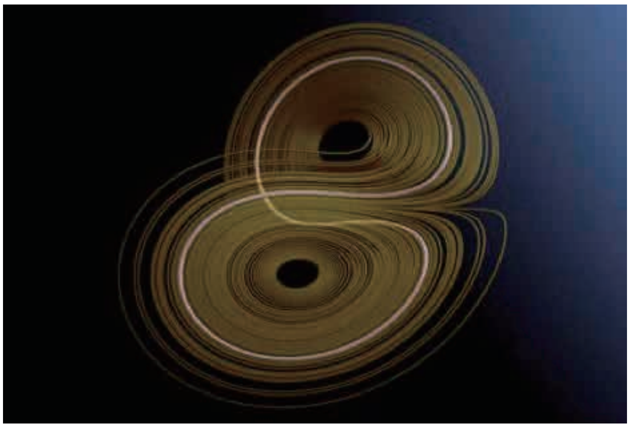

Figure 2: The Lorenz attractor defined by the system of differential equations
dx/dt = 10(y–x),dy/dt = 28x – y – xz,dz/dt = xy – (8/3)z,
and a Lorenz knot (white curve) [3].

On the other hand, modular knots are defined for a matrix $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$ with integer coefficients, $ad - bc = 1$, and $a + d > 2$. To be precise, the modular knot is defined in the homogeneous space $SL_2(\mathbb{Z}) \backslash SL_2(\mathbb{R})$, which is diffeomorphic to the knot complement of a trefoil knot in S^3. Figure 1 shows an example of modular knots (green curve) with the trefoil knot (yellow curve). These two classes of knots have entirely different origins. Ghys proposed that any Lorenz knot is realized as a modular knot. The figure shows that the green knot and yellow knot are tangled up. The green knot twines around the yellow knot 149 times. This winding number is called a linking number of two knots. Thus, the counting problem occurs again. Is it possible to count the linking number for a given modular knot? To solve this problem, Ghys established that "the linking number equals the Rademacher symbol" defined for the non-holomorphic modular form $\log\Delta(\tau)$. Thus, it is computable. Again, modular forms appear. The proof consists of two parts. The first part is the topological relation between the linking number and the Rademacher symbol. The second part is a closed explicit formula for the Rademacher symbol shown by Dedekind in 1892. Further, Ghys put a simple question on the linking number of two modular knots.

A DECADE LATER, Duke-Imamoglu-Tóth [1] suggested an answer to his question. First, they constructed a suitable analog of the Rademacher symbol. They showed that this Rademacher symbol gives the number of intersections of a modular knot and the Seifert surface for another modular knot using Birkhoff's theorem. Here, a Seifert surface is a surface whose boundary is a given knot. Therefore, we observe that this is the linking number of two modular knots, which answers Ghys' question.

Figure 3: An example of the Seifert surface for a knot (denoted by 7_4 in the classification table of knots).

Does the above result allow us to count the linking number of two modular knots? The answer is no. To do so, we need an arithmetic formula for their analog of the Rademacher symbol. In my work [7], we studied another non-holomorphic modular form named the "hyperbolic Eisenstein series" and gave a simple explicit formula for the Rademacher symbol. This result is a counterpart of Dedekind's classical result. Recently, I obtained another generalization of Ghys' result in collaboration with J. Ueki. Amazingly (or as we imagined), a new type of non-holomorphic modular form has an important role there. In closing, I want to end with the conference's title held at the MPIM in 2017. "Modular forms are everywhere."

Acknowledgements
I would like to express my gratitude to Jos Leys for providing a beautiful imagery of modular knots. I also thank Herbert Gangl for giving me a lovely metallic Seifert surface. This work was supported by JSPS KAKENHI Grant Number JP20K14292.

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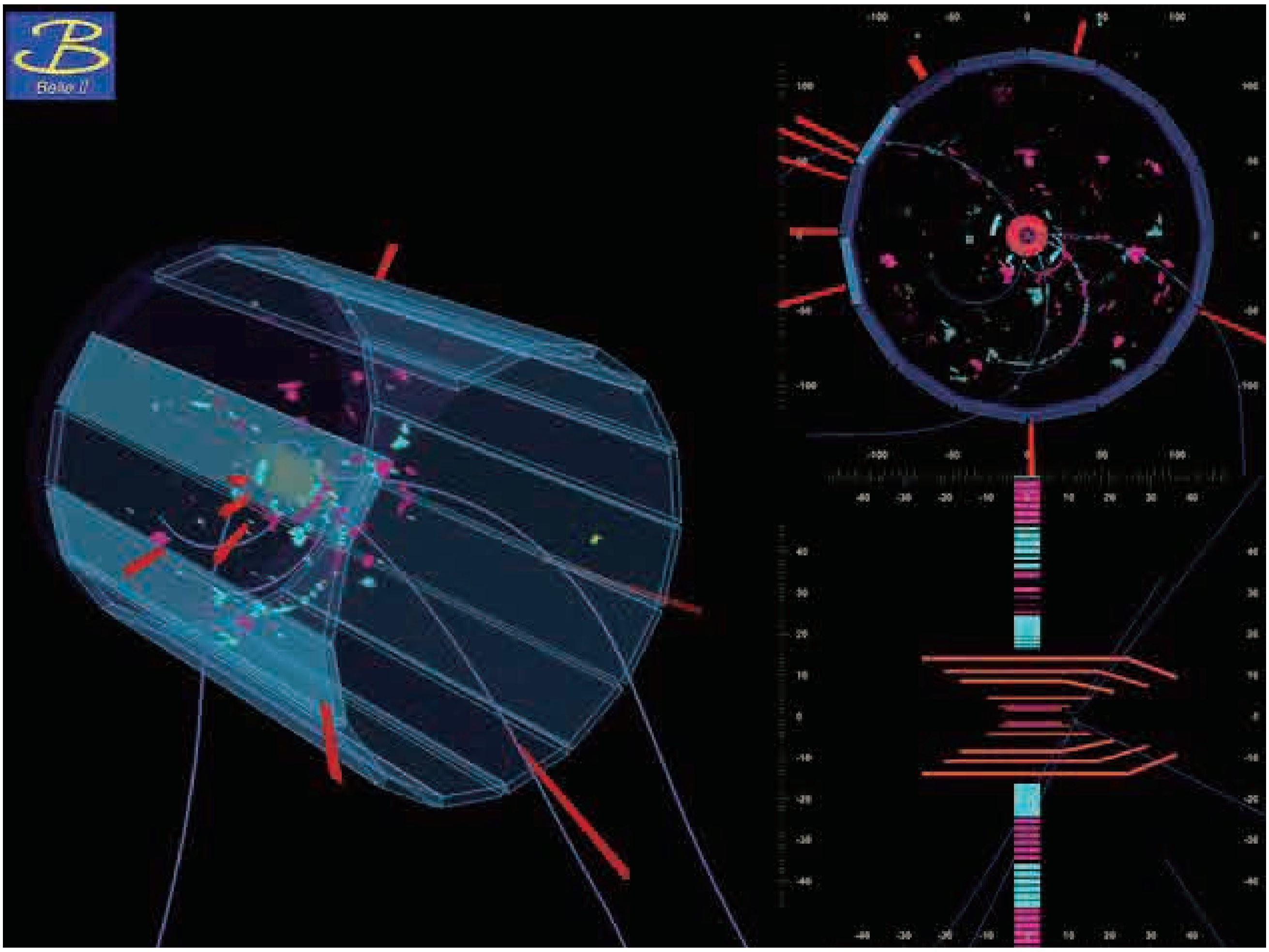
Explore New Physics with Belle II Experiment at the Intensity Frontier



Event display of the particle detection in the Belle II experiment. The particles are generated by the collision of electrons and positrons.

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Dark matter, the dominance of matter in the universe, and many other phenomena still cannot be explained by the current framework of theories that comprise the Standard Model (SM) of particle physics. One useful approach to exploring new physics beyond the SM is to create an environment just like the one that existed during the beginning of our universe using a colliding-beam accelerator and then precisely measure the decay reactions under these conditions. Observing the quantum effect of new particles on the decay transformations of particles shows what we assume to be new physics. We have succeeded in collecting data by operating the Belle II detector and superKEKB accelerator since April 2018. The detector upgrade and data analysis are being performed in parallel. In the coming years, these data will help us understand the origins of matter and the universe.

INTRODUCTION

Quarks and leptons are the elementary particles that constitute the matter of our universe. Gauge bosons, such as photons, are defined as force carriers, and the Higgs boson (the so-called "God particle") explains where the mass of these particles originates from. The properties and physical behavior of these elementary particles are described through the theory called the Standard Model (SM) of particle physics. Although the SM is believed to be theoretically self-consistent and has demonstrated huge successes, it still leaves some phenomena unexplained, for example, dark matter and material dominance in the universe. To explore new physics beyond the SM, one useful approach is to create an environment that imitates the environment that existed when the universe began and then precisely measure the particle decay under these conditions. If there are new particles involved beyond those in the SM theory and they participate in the particle decays, their quantum effect could be measured as a small difference from the results that the SM theory would predict. Belle Ⅱ is an experiment dedicated to exploring new physics beyond the SM in the flavor sector at the beam intensity frontier by measuring the decay products from electron and positron collisions in the SuperKEKB accelerator. The SuperKEKB accelerator is located at KEK, Tsukuba, Japan. It is designed to achieve the world's highest instantaneous luminosity ($6.5 \times 10^{35} cm^{-2}s^{-1}$) by colliding electrons (7 GeV) and positrons (4 GeV). Belle Ⅱ aims to collect 50 ab^{-1} integrated luminosity (~60 billion B meson pairs) in an operational span of 10 years. This massive amount of data allows the precise measurement of rare heavy flavor decays, such as B meson decays.

B ANOMALY

Lepton universality is an idea predicted by the SM. According to this theory, all three types of charged lepton particles (electron, muon, and tau) should interact in the same manner with other particles. In the decays of $B \to D^{(*)} e\nu$, $B \to D^{(*)} \mu\nu$, $B \to D^{(*)} \tau\nu$, all three types of decay transformations should be created at an equal rate once differences in their mass are accounted for. Moreover, the new particles appearing in the model beyond SM should be sensitive to the heavy particles. In other words, the decay rate of $B \to D^{(*)} \tau\nu$ should be larger than $B \to D^{(*)} e\nu$ and $B \to D^{(*)} \mu\nu$. Figure 1 shows the ratio of

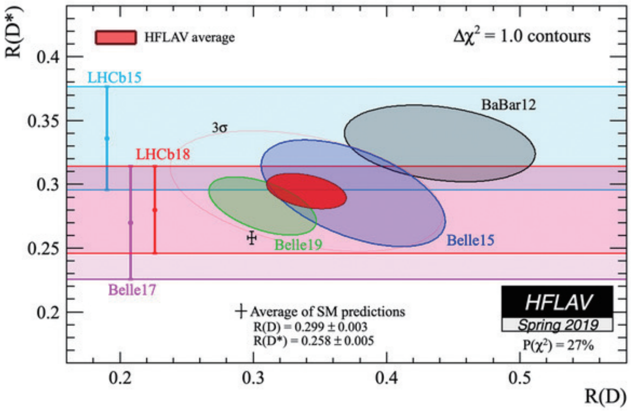

Figure 1. Ratio value of R(D) and R(D*) [1]. Marker is the prediction of SM, and each color region shows measurement results with uncertainties. The red circle represents the average value of results from all the measurements. The average measurement result is 3σ (standard deviation) away from the SM prediction.

$R(D^{(*)}) = Br(B \to D^{(*)} \tau\nu) / Br(B \to D^{(*)} l\nu)$, l = e, μ, and $Br((B \to D^{(*)} \tau\nu)$ denotes the branch fraction of $B \to D^{(*)} \tau\nu$. The red circle represents the average value of measurement results that slightly deviate from the theoretical prediction of SM with an uncertainty of 3σ (standard deviation) but still below the 5σ, which would be needed to claim that this difference indicates a discovery. This evidence of deviation is called a "B anomaly" in the particle physics field. To place this anomaly in context, it is necessary to collect much more data to reduce the statistical fluctuation and improve the systematic uncertainties.

OPERATION AND UPGRADE OF THE BELLE II DAQ SYSTEM

The Belle Ⅱ experiment began collecting data in April 2018. It recorded 74.10 fb^{-1} data with data taking efficiency of 84.2% during the last run period from March 2020 to June 2020. At 20:34 on June 15, 2020, the SuperKEKB accelerator achieved the world' s highest instantaneous luminosity for a colliding-beam accelerator. As shown in Figure 2, the current record of $2.40 \times 10^{34} cm^{-2}s^{-1}$ was obtained at 00:53 JST on June 21, 2020 [2]. SuperKEKB is planning to increase the luminosity to approximately 40 times of the new record in the coming years. At the same time, Belle Ⅱ needs to record the data without any leaking under these conditions. Currently, there is an attempt to upgrade the Belle Ⅱ data acquisition (DAQ) system to handle the data flow with transmission speeds from 1 to 10 Gbps. Corresponding hardware and software developments have been nearly accomplished, the current system would be replaced by the beginning of 2021. The new system will be sufficiently capable of handling the data flow for the rest of Belle Ⅱ' s operation time even if it achieves luminosity 40 times greater than the current record.

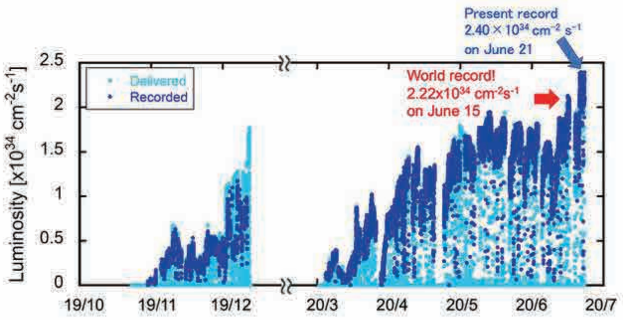

Figure 2. Instantaneous luminosity of SuperKEKB measured from October 2019 to June 2020 [2].

DATA ANALYSIS

Belle Ⅱ is still at the beginning of its operation. First, we are attempting to analyze the data and to understand the detector. For example, we have conducted a study to correct the momentum bias of the charged particles reconstructed by the Belle Ⅱ detector [3]. Momentum bias can directly affect the detection of all particle decays involved in charged particles. When we accumulate more data, the systematic uncertainties will become more critical than the statistical uncertainties. Simultaneously, we also established the analysis framework to reconstruct the $B \to D^{(*)} l\nu$ decays. The first measurement of the $B \to D^{(*)} l\nu$ branching fraction using the Full Event Interpretation algorithm based on 34.6 fb^{-1} of Belle Ⅱ data has been accomplished [4], and the result is

$$Br(B \to D^{(*)} l\nu) = (4.51 \pm 0.41_{stat} \pm 0.27_{syst} \pm 0.45)\%$$

Here, 0.41 and 0.27 are the statistical and systematic uncertainties, respectively. This is lower than but in agreement with the current world average value.

REMARKS AND FUTURE PROPECTS

The operation of the Belle Ⅱ detector and superKEKB accelerator is proceeding smoothly. We believe that we can accumulate 1 ab^{-1} data that is compatible with Belle's full data by the end of 2021. Belle is Belle II's predecessor. If 5 ab^{-1} data can be accumulated by the end of 2023, that should be sufficient to let us settle the "B anomaly." At the same time, Belle Ⅱ is exploring the new physics using many different decay channels in parallel [5]. There will be more new results emerging in the forthcoming years.

Acknowledgements

This work was supported by Grants-in-Aid for Scientific Research, KAKENHI-JSPS International Research Fellow Grants No. 18F18324.

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[2] SuperKEKB collider achieves the world' s highest luminosity, https://www.kek.jp/en/newsroom/2020/06/26/1400/

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[4] Belle Ⅱ Collaboration, Measurement of the semileptonic anti-$B^0 \to D^{*+} l$-ν branching fraction with fully reconstructed B meson decays and 34.6 fb^{-1} of Belle Ⅱ data, arXiv:2008.07198 (2020).

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IAR Core Faculty Committee

The IAR Core Faculty Committee is composed of the Institute Director, Deputy Directors, Full-Time Faculty Members, and member of the clerical staff, who promote the Institute's activities, and make proposals to the IAR Committee.

Yoshiyuki
SUTO
Director

Affiliation : Director of Nagoya IAR / Professor of the Graduate School of Humanities
Research Field : Ancient Greek History

Research Interests

My research interests include Aegean Archaeology, Ancient Greek History, and especially the study of contact and interaction between Greek and Egyptian culture in the Hellenistic period. As a member of Akoris Archaeological Project I have been working in Middle Egypt for the purpose of elucidating the history of local society under the Ptolemaic rule.

Hitoshi
SAKAKIBARA
Deputy Director

Affiliation : Deputy Director of Nagoya IAR / Professor of the Graduate School of Bioagricultural Sciences
Research Field : Molecular Plant Physiology, Phytohormone

Research Interests

My research interest is to understand how plants manage their growth and development under abiotic stress conditions, uch as nitrogen limitation. Plant orchestrates a number of cues including phytohormone actions and metabolic responses to coordinate its development and metabolism at a whole-body level. I am studying molecular basis of this topic with focusing on nitrogen-dependent regulation of phytohormone biosynthesis and signaling.

Ichiro
TERASAKI
Deputy Director

Affiliation : Deputy Director of Nagoya IAR / Professor of the Graduate School of Science
Research Field : condensed matter physics (experiment)

Research Interests

Ichiro Terasaki synthesizes new materials, investigates their transport and magnetic properties, and develops functions hidden there. His major research activity has been devoted to the thermoelectric properties of transition-metal oxides including the layered cobalt oxides, and recently extended to giant nonlinear conduction in strongly correlated systems such as conducting organic salts and layered ruthenates. His recent interest extends to exotic magnetic materials such as room-temperature ferromagnetic semiconductors and spin-liquid candidates.

Hiroko
TAKEDA
Deputy Director

Affiliation : Deputy Director of Nagoya IAR / Professor of the Centre for Asian Legal Exchange
Research Field : Political Sociology, Politics

Research Interests

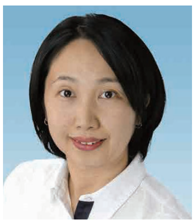
My research can be mapped out in an intersection of the following three major elements; political sociology, gender and Japan / UK. Political Sociology is my disciplinary background. In particular, I developed a keen interest in the studies on governmentality. As for gender, I have long been interested in gender issues and the core of academic questions that I have continuously explored in my extant work--the ways in which the world of the everyday life is linked with the state system --was formulated as an outcome of my effort to examine gender issues with reference to governmentality. Finally, Japan has been my primary source of case studies and recently, I also started to explore the British cases.

Yukinori
KAWAE
Full-Time Faculty

Affiliation : Associate Professor at Nagoya IAR
Research Field : Egyptian Archaeology, Pyramid, 3D Survey

Research Interests

My research interests lie in the field of Egyptian archaeology, particularly in 3D surveys of ancient megalithic structures and excavations of ancient settlements. My academic career started the excavation of the Lost City of the Pyramids at Giza. Soon after the introduction of 3D technology in Egyptian archaeology, I began conducting an interdisciplinary research project to complete 3D surveys of pyramids. Recently, I expanded the collaborative research to include a television production company as Open Innovation Project. My use of 3D data challenges the unprecedented empirical analysis approach to understanding the mystery of the pyramids' construction.



Satomi
KANNO
Full-Time Faculty

Affiliation : Associate Professor at Nagoya IAR
Research Field : Plant Physiology, Plant nutrients

Research Interests

My research interest is understanding plant growth adaptation mechanisms according to environmental nutrients conditions. Plant senses internal and external ion level and controls the ion transport system to optimize their growth. I am working on these mechanisms focusing on phosphate, one of the macronutrients for plant growth, by using molecular biology technics and imaging technologies to trace ions in the living plants.

Affiliation : Designated Lecturer at Nagoya IAR
Research Field : Observational Cosmology, Astronomy

Atsushi
J. NISHIZAWA
Full-Time Faculty

Research Interests

My research interest ranges from theoretical aspects of cosmological model that explains accelerating expansion of the Universe, to the theory of galaxy formation. To reveal such problems in the Universe, large astronomical data obtained by telescope is used. Recently I am working on the photometric redshift that determines the distance to galaxies. The redshift of galaxies are of particular importance for doing both cosmology and astronomy. I am also interested in the methods of data analysis including machine learning.

IAR Steering Committee

The IAR Steering Committee plan, discuss, and decide on the Institute's academic activities.

Naoshi
SUGIYAMA
Steering Committee

Affiliation : Vise President of Nagoya University / Director of NAIAS / Professor of the Graduate School of Science
Research Field : Cosmology, Astrophysics, Structure Formation in the Universe

Research Interests

I am working in the field of cosmology to understand dark components in the Universe. The Universe is known to consist of various components including atoms, photons, dark matter and dark energy. The ultimate goal of modern cosmology is to understand the nature of dark matter and dark energy. Since dark matter plays an essential role for the formation of structure through gravity, and dark energy controls expansion of the Universe itself, both have significant impact on structure formation in the Universe. Utilizing the observation data of structure of the Universe, including galaxies, clusters of galaxies, large-scale structure of the Universe, and temperature fluctuations of cosmic microwave background radiation, which is a fossil of big bang in the very early Universe, I try to reveal the nature of dark matter and dark energy.

Mitsuru
SUGIMOTO
Steering Committee

Affiliation : Professor of the Graduate School of Mathematics
Research Field : Partial differential equations

Research Interests

Various phenomena of nature can be treated mathematically by describing them in the language of partial differential equations (PDE). Through the analysis, I aim to extract new principles which comprehend concrete phenomena. As a methodology of PDE, many properties of the solutions to PDE can be deduced from their characteristics, and I employ this idea to investigate quantitative properties of solutions like size, regularity, and so on. Simultaneously I proceed with the study of Fourier analysis as an important tool for such analysis.

Tetsuya
OKAJIMA
Steering Committee

Affiliation : Professor of the Graduate School of Medicine
Research Field : Biochemistry, Glycobiology

Research Interests

My research has focused on biochemical and biological analyses of O-glycan modification on glycoproteins. Previous studies revealed that unique glycans such as O-fucose and O-GlcNAc regulate Notch signaling and Notch-dependent biological processes. Currently, I am investigating how O-glycan modification is coordinated to fine-tune Notch signal strength essential for developmental control and homeostasis. Given that Notch signaling pathway is associated with many human diseases, elucidation of molecular mechanisms how O-glycans control Notch activity will be of great pharmaceutical interest.

Takahiro
SEKI
Steering Committee

Affiliation : Professor of the Graduate School of Engineering / Director of Center for the Studies of Higher Education
Research Field : Photoresponsive polymer thin films

Research Interests

Photoresponsive organic and polymeric materials are attracting much attention due to great potential in next-generation photonics technologies. My major research interest is to study photoresponsive (mostly photochromic) thin films of polymeric liquid crystals. The alignment control of liquid crystal that is essential in liquid crystal photonics can be achieved by irradiation with linearly polarized light to the surface photoresponisve layer on a substrate or a free surface. Based on this phenomenon, we are extending the possibilities of photoalignment process for orientation control of various functional materials.

Yoshinobu
BABA
Steering Committee

Affiliation : Professor of the Graduate School of Engineering / Director of Institute of Nano-Life-Systems
Research Field : nanobioscience, biomedical engineering

Research Interests

The research efforts in my laboratory have been focused on the development of nanobiodevices for biomedical applications and healthcare, including single cancer cell diagnosis for cancer metastasis, circulating tumor cell (CTC) detection by microfluidic devices, nanopillar devices for ultrafast analysis of genomic DNA and microRNA, nanopore devices for single DNA and microRNA sequencing, nanowire devices for exosome analysis, single-molecular epigenetic analysis, AI-powered nano-IoT sensors, quantum switching *intra vital* imaging of iPS cells and stem cells, and quantum technology-based cancer theranostics.

Sayaka
OKI
Steering Committee

Affiliation : Professor of the Graduate School of Economics
Research Field : History of Science and Technology

Research Interests

History of Science in the 17-18th century of France, especially on the relationship between the government and academic institutions of science; Concept of "Economy" and its relationship with natural sciences in the latter half of the 18th century

IAR Visiting Professor & Designated Professor

Takaho
ANDO
Visiting Professor

Affiliation : Visiting Professor at Nagoya IAR / Professor at Chubu University
Research Field : History of Social Thoughts

Research Interests

Research on History of Social Thoughts, especially on French Enlightenment and Liberalism.

Yasuro
ABE
Visiting Professor

Affiliation : Visiting Professor at Nagoya IAR
Research Field : Medieval Japanese Culture and Texts

Research Interests

My research focuses on the religious texts of medieval Japan, emphasizing their context as objects of religious cultural heritage. I have strived to demonstrate how religious texts, images, and other objects have been used, transmitted, and understood from the Middle Ages through the present day. Through the analysis of concrete examples—such as the cult of Prince Shōtoku, and various conceptions of the "sacred" in medieval Japan—I have demonstrated that these texts mutually interact not only with each other, but also with external works of literature, performative arts, and iconography.

Dapeng
CAI
Visiting Professor

Affiliation : Visiting Professor at Nagoya IAR / Professor at Nanzan University
Research Field : International Economics

Research Interests

An increasing number of challenges facing humanity today, such as the reduction of the emission of the greenhouse gases, or the protection of global commons, all require intensive cooperation by many countries. My research aims at analyzing the international negotiation processes that are underlying the formation of the needed international cooperation. Besides the issue of emission reductions, I also examine other issues that require international negotiations-in particular, those between the North and the South-such as the protection of intellectual property rights, as well as the setting of investment rules or production standards.

Miki
KAWACHI
Visiting Associate Professor

Affiliation : Visiting Associate Professor at Nagoya IAR
Research Field : Plant Physiology, Zinc Biology

Research Interests

My research mainly concerns the transport of micro-nutrients in living organisms. All organisms need elements like zinc or manganese in very minute amounts, however, even a small excesses can be harmful. Specialized transport proteins are the principal means of nutrient movement within and between cells. I am interested in the structure of those proteins and how structural differences might affect their function. I am working with diverse model organisms ranging from microbes to all the way to fruit trees.

YLC Program Faculty

YLC Faculty members are promising young researchers recruited under the Nagoya University Young Leaders Cultivation Program (YLC Program).

Tomohiro
ABE
Young Leaders Cultivation Program Faculty
(YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Kobayashi Maskawa Institute (KMI)
Research Field : elementary particle physics

Research Interests

My interest lies in physics beyond the standard model of elementary particles. One of my current research topics is dark matter. I have been revisiting a calculation of the dark matter energy density in models widely studied in the particle physics community. I found that dark matter-Higgs coupling should be much larger than the value obtained in the previous works. This result is testable by studying the decay process of the Higgs boson into dark matter particles. I have also been working on physics on the Higgs boson(s) with focusing on various ongoing and planned experiments in the future.

Masaru TAKEUCHI

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Engineering
Research Field : Micro-nano manipulation

Research Interests

My research interests are micro-nano manipulation, microfluidics and optoelectronic devices for biological applications. Especially, developments of small devices for three dimensional assembly of cell structures using self-assembly process has been conducted. Micromanipulation devices using solid-liquid phase change were also developed to handle single cells, or actuate small amount of liquid. The assembled 3D cell structures by the developed devices will be used as in vitro models of our organs.

Kazuhide SATO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Medicine
Research Field : Respiratory Medicine, Oncology

Research Interests

Lung cancer is the most common cause of cancer-related deaths, and the cure rate of lung cancer is still under 20%, therefore, there is urgent need for new treatments. I aim to develop new innovative cancer therapy with a concept "less toxic, more anti-tumor effect". Along with different approaches from conventional cancer therapies, I have been studying about photo-activated cancer therapy in order to destroy only cancer cells inside body. I would like to develop new technologies that could cause effects only on the cancers with a multidisciplined approach.

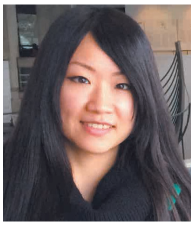
Tsutomu FUKUDA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Science
Research Field : Particle Physics, Astrophysics

Research Interests

A fundamental particle "neutrino" is a key for revealing the origin of the matter dominated universe. I have carried out accelerator based neutrino experiments with nuclear emulsion detector. So far we provided the final evidence of nu_mu -> nu_tau neutrino oscillation with tau neutrino appearance in a muon neutrino beam from CERN in the OPERA experiment. Then I have established and am promoting a new experimental project (NINJA Experiment) to measure neutrino interactions precisely at J-PARC as the PI. Precise measurement of neutrino-nucleus interactions is essential for observing the neutrino-CP violation which is an important hint for matter-antimatter asymmetry in our universe.



Yuri FUJII

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Science
Research Field : Astropysics, Planetary Science

Research Interests

I am working on the formation theory of planets and satellites in our solar system and also in extrasolar systems. Planets form in gaseous disks called protoplanetary disks, which are the leftover of star formation. Recent observations show wide variety of structures in protoplanetary disks including the clue of ongoing planet formation. I perform magneto-/radiation hydrodynamic simulations to investigate the dynamics of protoplanetary disks and the manner of the gas flow onto a planet in the disk. These simulations provide the formation environments for planets and satellites. I am also interested in chemical evolution of protoplanetary disks, modeling of circumplanetary disks, and orbital evolution of satellites.

Hidenori TAKEUCHI

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Institute of Transformative Bio-Molecules (ITbM)
Research Field : Molecular biology in plant reproduction

Research Interests

Fertilization between male and female gametes of the same species is fundamental for seed production and species maintenance in higher plants. My research interests are in species-specific male-female recognition mechanisms, including prezygotic pollen tube guidance and postzygotic chromosome maintenance. I will especially try to identify key factors involved in these processes. I finally aim to understand the species-specific mechanisms in plant reproduction, which could lead to technologies for generating useful hybrid plants.

Hironao MIYATAKE

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Science
Research Field : Cosmology, Weak Gravitational Lensing

Research Interests

My research interests lie in observational cosmology. Cosmic acceleration discovered in the late 1990s is one of the most mysterious phenomena in physics and astronomy, which indicates the existence of dark energy or the modification to general relativity. I have been working on exploiting weak lensing observables, the subtle distortion in the shapes of distant galaxies due to massive foreground structures, to extract the nature of cosmic acceleration from big imaging data taken by Hyper Suprime-Cam (HSC) at the Subaru Telescope. I am also involved in upcoming international galaxy surveys such as Large Synoptic Survey Telescope (LSST) and NASA's Wide Field Infrared Survey Telescope (WFIRST).

Shingo KAZAMA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Kobayashi-Maskawa Institute (KMI)
Research Field : Particle Physics, Astroparticle Physics

Research Interests

Despite the overwhelming evidence for dark matter from astronomical and cosmological indications at various scales, a clear evidence of a particle which explains these observations remains absent. I'm involved in the XENON project to search for the low-energy interactions of galactic dark matter with nuclei. The XENON collaboration has built the XENON1T detector, the most sensitive detector ever built, but no clear evidences of dark matter have been found. We are currently upgrading the XENON1T detector by enlarging the target xenon mass from 2 to 6 tonnes. The new experiment will start its operation in 2019, and this will allows us to explore promising parameter spaces towards a first discovery.

Teppei KITAHARA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Kobayashi-Maskawa Institute (KMI)
Research Field : High energy physics, Flavor physics

Research Interests

I am interested in searching for physics beyond the standard model through precision measurements of the properties of standard model particles, and especially my main focus is on flavor physics. I am going to improve the standard model predictions of B-meson decays and also investigate CP violation in rare kaon decays. I am broadly interested in testable physics of various experiments, and I hope to stimulate interactions between theory and experiment.

Yuki SATO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Science
Research Field : Quantum gravity

Research Interests

Modern physics incorporates Einstein's general relativity and quantum mechanics. The former associates gravity with the bending of spacetime, and the latter explains characteristic properties of matters at short distances. According to general relativity, the spacetime curves due to the existence of matters, and matters indicate quantum characteristics at short distances. Therefore, gravity is supposed to show quantum mechanical effects, and those effects would become important around the Planck scale. The theory that describes quantum effects of gravity, quantum gravity, is my field of research. I mainly study discrete approaches to quantum gravity.

Natsuki TAKADA-TANAKA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Bioagricultural Sciences
Research Field : Plant Molecular Physiology, Biochemistry

Research Interests

Plants live in a frequently changing environment from which they cannot escape and have signaling mechanisms to adapt to new conditions. Calcium, lipid and protein are involved in the signaling pathways. However, limited information on signal transduction between different signaling systems is available. I focus on a new type signal transducer PCaP1 which can convert Ca2+ signal to phospholipid signal on plasma membrane. Thus I investigate PCaP1-related physiological processes, such as stomata closure and root hydrotropism, to reveal a novel mechanism to adapt a new environmental conditions.

Yongchao CHENG

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Humanities
Research Field : International Relations in 17-19th century East Asia

Research Interests

By putting Joseon Korea as a mediator between Tokugawa Japan and Ming-Qing China, which have not established formal diplomatic relation in 17-19th centuries, I demonstrate and empirically analyze, that China and Japan had mediated political connections, aiming to rebuild the history of East Asia by using the approach of global history. Instead of just adding up of several bilateral relations, such as Japan-Korea and Korea-China, I am putting the historical pieces scattered in Chinese, Japanese, Korean documents together and confronting simultaneously the trilateral relation of countries, to illuminate the entanglements and interactions among early-modern East Asian countries.

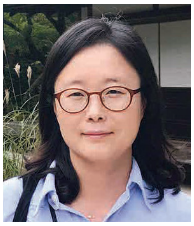
Hiroki FUJINO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Graduate School of Mathematics
Research Field : complex analysis, function theory

Research Interests

My research topic is on the global properties of the infinite dimensional Teichmuller spaces. In particular, I am mainly interested in degeneration phenomena of Riemann surfaces on the boundaries of the Teichmuller spaces. The Teichmuller space is a space which parametrizes all quasiconformal deformations of a given surface. If the given surface is of finite type, the degenerations to nodal surfaces appear as a dense subset of the boundary. However, in the case of infinite type surfaces, various degeneration phenomena are obtained besides the degenerations to nodal surfaces.



Soon-Ki HAN

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant Professor at Nagoya IAR and Institute of Transformative Bio-Molecules (ITbM)

Research Field : Plant stomata development

Research Interests

Plant stomata are cellular valves surrounded by a pair of guard cells that impact plant growth, sustenance, and atmospheric environment. Stomatal stem cells are produced and transiently amplified on the leaf surface, and their stem cell activity is terminated before differentiation. I aim to understand the direct roles of transcription factors in a dynamic alteration of gene expression that is responsible for stomatal differentiation especially in maintenance and termination of stomatal lineage stem cells.

Ai SUGIE

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Environmental Studies

Research Field : Human Geography, Areal Studies

Research Interests

Bangladeshi Migrants in Saudi Arabia and transnational networks of Islamic Revival. This study explores the socio-spatial structure and socio-economic backgrounds of Bangladeshi migrants in Makkha and examines their social-cultural impacts on Islamic revival movements in the city and their hometowns in Bangladesh. Research 2: Pluralistic economy and alternative development. This study discusses the possibility of an alternative development based on a pluralistic economic system that reciprocity among people and between human and nature are prioritised over market economy success. Research 3: Water resources problems in Rohingya refugee camp areas in Bangladesh.

Yumi BAMBA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Division for Integrated Studies, Institute for Space-Earth Environmental Research

Research Field : Solar Physics, Space Weather

Research Interests

Solar eruptions, such as "solar flares" and "coronal mass ejections (CMEs)" are sometimes impact to space environment around the Earth. However, onset mechanisms and propagation processes of those phenomena are not yet revealed. Therefore, our ability of "space weather forecast", which predict disturbances of space environment near the Earth, does not satisfy requirements from modern society, which rapidly promote space development. I aim to understand the onset and propagation processes of solar eruptions by comparison of various observational data and numerical modelings.

Kazuya FUJIMOTO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Department of Applied Physics, Graduate School of Engineering

Research Field : Condensed matter physics (theory)

Research Interests

Non-equilibrium phenomena emerge in various length-scales ranging from small atomic and molecular clusters to fluid dynamics in our daily life. I have been interested in universal aspects of non-equilibrium phenomena, and have recently studied relaxation dynamics, wave and vortex turbulence, and chaos in ultracold quantum gases. The system is a vapor of several atomic species at very low temperature, and is recognized as one of the promising playgrounds for studying such non-equilibrium phenomena in quantum many-body systems.

Yoko MIZUTA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Institute of Transformative Bio-Molecules (ITbM), Nagoya University

Research Field : Molecular biology, Plant reproduction

Research Interests

In the flowering plants, sexual reproduction occurs in a flower. In the flower, pollen lands on the female tissue, and pollen germinates pollen tube and deliver the sperm to the egg cell. After that, fertilization occurs. During this process, it is necessary to fertilize without waste both males (pollen tubes) and females (ovules) to produce more seeds in nature, but the whole picture of such precise plant fertilization mechanism is unclear. To understand this mechanism, two-photon imaging, expression and phylogenic analyses will be performed. I developed deep-and live-imaging technics using two-photon microscopy. The pollen tube mediated gene modification technology is also developed.

Koji MURATA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Institute for Advanced Research / Graduate School of Humanities

Research Field : History, Byzantine Studies, Diplomatics

Research Interests

I am interested in various subjects related to Byzantium, the Medieval Roman Empire (ca. 4th Century to 1453). My current research explores social functions of byzantine documents issued by emperors and state officials in the 13th and 14th centuries. In particular I am investigating to what extent written documents were utilized to regulate relationships between Byzantium and other polities.

Aaron CHAN

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Mathematics
Research Field : Representation theory, category theory

Research Interests

I research in the representation theory of algebras and related structures, which originates from the approximating (i.e. `representing') abstract mathematical objects using linear algebra. I am particularly interested in tilting theory. This studies different methods in modifying a category of representations in a way that preserves homological properties. I am also involved in a similar theory-cluster-tilting theory-which is a theory in the algebraic analogue of resolution of singularities.

Claudia MARTINEZ-CALEDERON

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Institute for Space–Earth Environmental Research
Research Field : Magnetosphere and Space Plasma Physics

Research Interests

My research project focuses on VLF/ELF emissions, their physical properties, generation and propagation. Currently my focus is on ground and satellite simultaenous and conjugated VLF events. I'm also an active member of the VERSIM workshop group and co-founder of their Journal Club.

Angela MENESES-GUTIERREZ

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Disaster Mitigation Research Center
Research Field : Crustal deformation

Research Interests

I study crustal deformation through geodetic observations (Global Navigation Satellite Systems (GNSS), Interferometric Synthetic Aperture Radar (InSAR), etc.), focusing on the analysis of earthquake-related processes. I am interested in distinguishing strain accumulation due to elastic processes in the Earth, released in the form of large earthquakes, from inelastic processes which are irreversible and cause strain to accumulate over geological time.

Chihiro INOSE

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Humanities
Research Field : History and Culture of Japan

Research Interests

My main research object is Japanese culture from the 12 century to the 15 century. I'm particularly interested in music performed in rituals. Many old Japanese music is not played now. However, musical scores still remain. The purpose of my research is to reconstruct music from these scores and to clarify the characteristics between music and rituals.

Daichi KASHINO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Science
Research Field : Astrophysics

Research Interests

The present-day Universe contains a variety of elements and is a rich world in which stars, galaxies, and life exist. I aim to understand the material evolution in the Universe. We are especially paying attention to a phenomenon called cosmic reionization that completed until about 1 billion years after the Big Bang. Cosmic reionization is a phenomenon in which the Universe, which was initially filled with electrically neutral hydrogen gas, was ionized by the ultraviolet rays emitted by stars and galaxies born in the early Universe, and is the first step in material evolution. We are carrying out various observations using large telescopes to understand the physical process of reionization.

Shunsuke KOSAKA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Humanities
Research Field : History, Ancient Roman, Late Antiquity

Research Interests

I am studying the history of the Roman Empire in Late Antiquity (c. 3rd to 8th centuries CE). My research subject is a historiographical work written by Ammianus Marcellinus (late 4th century) and the city of Rome, where the author lived and composed his writings. I am trying to clarify the social and political background of the text as well as the author's view against them.

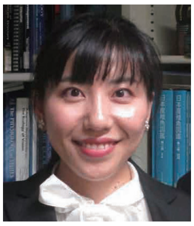
Tomoya NAKAYAMA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Bioagricultural Sciences
Research Field : Animal physiology, Molecular biology

Research Interests

In temperate zones of the earth, dynamic environmental fluctuations occur at the annual seasonal cycle. To cope with these seasonal changes, many animals adapt their physiology and behavior. Although some of these seasonal activities, such as reproduction, growth and hibernation are known to be controlled by endogenous annual rhythmicity, which is called circannual rhythm, in some animals, the molecular mechanism is still unknown. We use medaka fish as a model to understand this mechanism.



Hanako HAGIO

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Bioagricultural Sciences
Research Field : Fish Neuroscience

Research Interests

Two ascending visual pathways to the telencephalon are present in mammals. However, some species of fish possess two visual pathways, while others one pathway. Our studies in several fish species suggest that the common ancestor of actinopterygians possessed two pathways, and later one pathway was lost in the common ancestor of acanthopterygians, which include many fishes for fisheries. We try to elucidate functions of visual pathways using genome editing and microscopic live imaging analyses on visually-evoked neural activities. We would like to find visual stimuli attractive for fishes and utilize its characteristics in fishing gear to contribute to the academic field and fisheries industry.

Hisashi HAYAKAWA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Institute for Space-Earth Environmental Research
Research Field : Space Weather, History, Solar Activity

Research Interests

Hisashi Hayakawa is working on historical space weather events and long-term solar activity based on the contemporary analog records. He consults analog records for sunspots, solar flares, geomagnetic measurements, and auroral sightings to reconstruct chronology and intensity of the space weather events, namely sequence of solar flares, interplanetary coronal mass ejections, geomagnetic storms, and auroral displays. He also analyses historical sunspot records to quantitatively reconstruct and improve long-term solar variability. Thus he chronologically extends the time series of the existing scientific databases for centuries and quantitatively contextualises the modern data into longer time series.

Manabu BESSHO-UEHARA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Science
Research Field : Biology, Evolution, Bioluminescence

Research Interests

Bioluminescence, light production by living organisms, is one of the most common traits of the animals on the Earth (75-90% of macroscopic individuals in the ocean can emit light). Bioluminescence evolved among diverse taxa independently, which is the best model to study evolution. The molecular mechanisms involved in the light emission are poorly understood except for a few well-studied animals. In addition, I recently discovered kleptoprotein, stealing protein from the prey, for bioluminescence. I study the molecular mechanisms involved in the luminescent reaction, luciferin and luciferase, to understand extreme convergent evolution of bioluminescence.

Toshiki MATSUSAKA

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Mathematics
Research Field : Number theory

Research Interests

Modular forms are vital objects in classical and modern mathematics. This theory plays a crucial role as a bridge between number theory, topology, harmonic analysis, arithmetic geometry, combinatorics, representation theory, mathematical physics, etc. My research interest is investigating the roles of its generalization called "non-holomorphic modular forms" in this wide range of fields. In particular, I have been working on it from the viewpoints of number theory and knot theory.

Qidong ZHOU

Young Leaders Cultivation Program Faculty (YLC)

Affiliation : Designated Assistant professor at Nagoya IAR and Graduate School of Science
Research Field : Particle physics and astrophysics

Research Interests

Dark matter, matter dominance universe, there are phenomena still could not be explained by the current framework of theory in particle physics, the standard model (SM). To explore the new physics beyond standard model, it is a useful approach to precisely measure the decay reactions under the environment just like the beginning of our universe which is created by colliding-beam accelerator. Belle II is an experiment dedicated to explore new physics beyond SM based on this approach. It has already started collecting data since April 2018. I am preforming the detector upgrade and data analysis in parallel. In coming years, these data will help us to understand the origins of matter and the universe.

Owing to COVID-19 concerns, most annual plans have been canceled or postponed. However, Nagoya University's Institute of Advanced Research (IAR) has launched several online seminars in 2020.

IAR Symposium

IAR Symposiums are aimed at communicating the established, novel, and cutting-edge research of Nagoya University to all of its members. Usually, we focus on two different fields: literature and social science, and natural science and engineering. June 6, 2020, IAR and the Institute of Innovation for Future Society jointly hosted a special online symposium, titled “Look into the Future—How Do Researchers Overcome the COVID-19 Crisis.” Six professors were selected as faculty representatives to give lectures on their respective specialties, practical problems, and experiences during the lockdown.The second symposium of this series, which center around literature and social science, held on January 22, 2021. The title of this symposium is “Worth and Contribution of Academic Discipline—Impacts of the Research and Dialogs.” We had guest speaker Dr. Susumu ANNAKA from the Waseda Institute for Advanced Study (WIAS). Three researchers from Nagoya University gave talks.

UBIAS Directors' Pre-Conference 2020

On October 12–14, 2020, University-Based Institutes for Advanced Study's (UBIAS's) online conference participated by directors worldwide was held. The University of São Paulo and The University of Western Australia organized the meeting. Nagoya IAR has played a central role as a steering committee of UBIAS. Dr. Suto, Director of Nagoya IAR, gave a talk on the Topic of the Year for 2020 and 2021. The UBIAS member institutes decided that the Topic of the Year for 2020 and 2021 was “Dialogue.” Directors presented their activities for UBIAS and engaged in active discussions.

2020 Young Leaders Cultivation Program

The Young Leaders Cultivation (YLC) Program is a strategic program of Nagoya IAR based on the premise that it is crucial to secure an appropriate quantity and quality of young researchers in order to sustain the development of outstanding education and research in the future. Nagoya IAR recruits and trains young faculty members regularly and systematically. In the academic year 2020, Dr. Chihiro INOSE (Graduate School of Humanities), Dr. Daichi KASHINO (Graduate School of Science), Dr. Shunsuke KOSAKA (Graduate School of Humanities), Dr. Tomoya NAKAYAMA (Graduate School of Bioagricultural Sciences), Dr. Hanako HAGIO (Graduate School of Bioagricultural Sciences), Dr. Hisashi HAYAKAWA (Institute for Space-Earth Environmental Research), Dr. Manabu BESSHO-UEHARA (Graduate School of Bioagricultural Sciences), Dr. Toshiki MATSUSAKA (Graduate School of Mathematics), and Dr. Qidong ZHOU (Kobayashi-Maskawa Institute for the Origin of Particles and Universe) were newly employed as designated assistant professors of the YLC program.

YLC Seminar

The YLC seminar is aimed at providing members with opportunities to understand each other's research interests to assist interdisciplinary collaboration research. The 22nd YLC Seminar was held on October 27 2020. Dr. Hiroki Fujino (YLC Assistant Professor of Nagoya IAR/Graduate School of Mathematics) discussed “How to make complicated Surfaces?” and Dr. Yongchao Cheng (Associate Professor of Tohoku University/ Former YLC Faculty) talked about “Japan’s diplomatic negotiation with Ming China via Tsushima Domain and Joseon Dynasty in the first half of the seventeenth century.” The 23rd YLC Seminar was held on December 22 2020. Dr. Yoko Mizuta (YLC Assistant Professor of Nagoya IAR/Institute of Transformative Bio-Molecules) discussed “Colorful Imaging of the Secret Life of Plants,” whereas Dr. Hironao Miyatake (YLC Assistant Professor of Nagoya IAR/Graduate School of Science) talked about “Shedding Light on Dark Sector of the Universe by Weak Gravitational Lensing.” The 24th YLC Seminar was held on March 23 2021. Dr. Hisashi Hayakawa (YLC Assistant Professor of Nagoya IAR/Institute for Space-Earth Environmental Research) discussed “Tentative reconstructions of extreme space weather events using historical archival records,” and Dr. Manabu Bessho-Uehara (YLC Assistant Professor of Nagoya IAR/Graduate

School of Science) talked about “How a fish steals a light from its prey.” Active discussions took place.

YLC Collaborative Research Grant

The YLC collaborative research grant was launched in 2018 to support interdisciplinary collaboration between YLC faculty. YLC faculty voluntarily organized the grant contents, schedule, and selection process. YLC selected two research groups for a year. One of the chosen groups was represented by Dr. Yuri Fujii (YLC Assistant Professor of Nagoya IAR/ Graduate School of Science); the project title was “Astronomical Phenomena in Historical Literature.” The other group was represented by Dr. Hisashi Hayakawa; the project title was “Feasibility Researchers on the Quantitative Environmental History: a Case Study for the Crisis of the 17th Century and Its Comparison with Other Historical Crises.”

IAR Freshmen Lecture Series

Targeting first-year students of the Nagoya University, this lecture series includes lectures delivered by members of the IAR Academy, IAR Faculty members, IAR Fellows, and Nagoya University researchers. The series was aimed at communicating the fun of academic research. In the academic year 2020, the following 14 lectures took place online:

1. “Science Started from Observation,”
by Professor Sumio Iijima
(Guest Professor of Nagoya University and Professor of Meijo University)

2. “The Research History of Particle Physics,”
by Professor Makoto Kobayashi
(Director of the Kobayashi Maskawa Institute and 2008 Nobel Laureate in Physics)

3. “The Dark Matter of the Universe,”
by Professor Naoshi Sugiyama
(Graduate School of Science, Director of NAIAS and Vise-President of Nagoya university)

4.“Material Science—Fun and Useful,”
by Professor Ichiro Terasaki
(Graduate School of Science and Deputy Director of Nagoya IAR)

5. “The Present in Historical Studies: Excavate the Hellenism Civilization,”
by Professor Yoshiyuki Suto (Graduate School of Humanities, Director of Nagoya IAR)

6. “How to Use Contemporary Economics,”
by Professor Jiro Nemoto (Graduate School of Economics)

7. “Visualize—Science About the Blessing of Nature,”
by Professor Ryo Kohsaka (Graduate School of Environmental Studies)

8. “Analyze Democracy,”
by Professor Hiroko Takeda (Graduate School of Law and Deputy Director of Nagoya IAR)

9. “Fascination with an Introduction to the History of Thought,”
by Professor Takaho Ando (Chuo University/Sixth Director of Nagoya IAR)

10.“Next-Generation Bio-imaging,”
by Professor Shigehiro Yamaguchi
(Graduate School of Science and Institute of Transformative Bio-Molecules)

11. “Genome Breeding to Solve the Food Crisis,”
by Professor Makoto Matsuoka (Graduate School of Bioagricultural Sciences)

12. “Are Chemically Reacting Molecules ‘Visible’?”
by Professor Akiyoshi Hishikawa (Research Center for Material Scienc)

13.“Chemistry of Anthocyanin—Make It Bloom the Blue Roses,”
by Professor Kumi Yoshida (Graduate School of Informatics)

14.“How Is the Brain Formed? Research on Cell Development,”
by Professor Takaki Miyata (Graduate School of Medicine)

Foreign PI Fellowship Program

The Foreign Principal Investigator (PI) Fellowship Program is a program that invites excellent researchers from foreign countries with outstanding research achievements for 3 to 4 months' fellowship to promote the University's academic research. In the academic year 2020, Dr. Olga Riklikiene (Professor of Lithuanian University of Health Sciences) and Dr. Yi-Fang Tsay (Distinguished Research Fellow of Academia Sinica) were selected for this fellowship. While they were visiting Nagoya University, they discussed collaborative research with PIs at Nagoya University. They also contributed to the education of young researchers by giving advice and lectures.


Dr. Olga Riklikiene


Dr. Yi-Fang Tsay

Awards

Dr. Hitoshi Sakakibara (Professor of Graduate School of Bioagricultural/Deputy Director of Nagoya IAR) received the Enid MacRobbie Corresponding Membership Award (American Society of Plant Biologists) (July 2020) and was recognized by Clarivate Analytics as one of its Highly Cited Researchers (November 2020).

Dr. Kazuhide Sato (YLC Assistant Professor of Nagoya IAR/Graduate School of Medicine) won the 47th Hyper Interdisciplinary Conference Research Award (April 2020), the Japanese Society of Chemotherapy's 5th Uehara Infection and Chemotherapy Research Award (September 2020), The Young Investigator Awards of the Japanese Cancer Association (Clinical) (October 2020), The 7th Young Investigator Awards of the Japan Society of Infrared Science and Technology (October 2020), and Mycosis Forum 2020 Best Presentation Award (November 2020).uate School of Science) won the Konica Minolta Photographic Science Encouragement Award (Jul. 2019).

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