科研費
KAKENHI

Frontline Scientific Research Projects Advanced in JAPAN

— Newly Selected Large-scale Research Projects under FY2018 —
Grant-in-Aid for Scientific Research

December, 2018

Ministry of Education, Culture, Sports, Science & Technology (MEXT)
Japan Society for the Promotion of Science (JSPS)

Foreword

Grants-in-Aid for Scientific Research (*Kakenhi*) are competitive funds disbursed for the purpose of making leapfrog advances in scientific research carried out based on the free ideas of researchers themselves—research in all fields of the humanities, social sciences and natural sciences, spanning the spectrum from basic to applied science. Grants-in-Aid are awarded through a peer-review selection process, and they support pioneering, cutting-edge research that provides the underpinnings for building a bountiful society.

Within the program, various grant categories are established to coincide with the objective, content and scale of research projects. Applications are solicited and screened under the terms of each of category. This booklet introduces research projects newly selected in FY 2018, namely under the categories Specially Promoted Research and Scientific Research (S), carried out by a single researcher or a relatively small number of researchers, and Scientific Research on Innovative Areas (Research in a proposed research area), carried out by multiple researches or a research group.

We will be pleased if the information provided this booklet is helpful in understanding the research activities being carried out in Japanese universities and other research institutions.

Research Promotion Bureau, Ministry of Education, Culture, Sports, Science & Technology (MEXT)
(http://www.mext.go.jp/a_menu/shinkou/hojyo/main5_a5.htm)

Japan Society for the Promotion of Science (JSPS)
(http://www.jsps.go.jp/english/index.html)

Contents

Grant-in-Aid for Specially Promoted Research of KAKENHI, FY2018
(Newly Adopted Projects)

Grant-in-Aid for Scientific Research (S) of KAKENHI, FY2018 (Newly Adopted Projects)

【Broad Section C】

【Broad Section D】

【Broad Section E】

【Broad Section K】

【Reference】

Grant-in-Aid for Specially Promoted Research

☐ Distribution by Research Area of the Newly Adopted Projects

Purpose and Description of Grant-in-Aid for Specially Promoted Research (excerpt from the "Application Procedures for Grants-in-Aid for Scientific Research-KAKENHI-"):

1) **Funding target**:
Outstanding and distinctive research plan, conducted by a single or a relatively small number of researchers, is expected to yield excellent research results and to open up a new scientific field

2) **Range of total budget (total budget throughout the research period)**:
200 milion to 500 million yen
The upper limit of the total budget per research project is set at 500 million yen. If truly needed, however, application exceeding this upper limit is not excluded.
※ Handling of research projects with a total budget exceeding 500 million yen
The reason why such a budget is needed should be stated in detail in the appropriate column of the research proposal document. The necessity of the budget will be scrutinized.

3) **Research period**: 3 to 5 years
※ If it is truly needed, application with a longer research period (up to 7 years) is possible.

4) **Number of research projects to be adopted**: Around 10 in total

【 New Projects 】

	Number of Applications			Total Grant Disbursements (FY2018)	Per-project Grants (FY2018)	
	Received	Adopted	Ratio		Average	Largest
			(%)	(Thousands of Yen)	(Thousands of Yen)	(Thousands of Yen)
Humanities and Social Sciences	11	1	9.1	73,000	73,000	73,000
Science and Engineering	73	8	11	826,700	103,338	145,100
Biological Sciences	21	3	14.3	223,800	74,600	91,000
Total	105	12	11.4	1,123,500	93,625	145,100

【 New and Ongoing Projects 】

	Number of Applications	Total Grant Disbursements (FY2018)	Per-project Grants (FY2018)	
			Average	Largest
		(Thousands of Yen)	(Thousands of Yen)	(Thousands of Yen)
Humanities and Social Sciences	5	399,300	79,860	96,600
Science and Engineering	45	3,733,300	82,962	162,400
Biological Sciences	16	1,268,700	79,294	117,000
Total	66	5,401,300	81,838	162,400

※ Figure reflects only direct funding

List of the Newly Adopted Projects for Grant-in-Aid for Specially Promoted Research of KAKENHI, FY2018

（1）Humanities and Social Sciences（1 Project）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05204	Hiroshi Ishida 40272504	The University of Tokyo, Institute of Social Science, Professor	A Comprehensive Study of Life Course and Inequality Using the Framework of Cumulative Advantages and Disadvantages	FY2018-2024	73,000 470,800

（2）Science and Engineering（8 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05205	Hiroaki Misawa 30253230	Hokkaido University, Research Institute for Electronic Science, Professor	Development and elucidation of highly efficient photoreaction systems using a strong coupling between nanocavity and plasmon	FY2018-2022	111,400 477,700
18H05206	Shigeru Yoshida 00272518	Chiba University, Graduate School of Science, Professor	High Energy Neutrino Universe explored by IceCube-Gen2	FY2018-2022	69,700 411,400
18H05207	Akira Furusawa 90332569	The University of Tokyo, Graduate School of Engineering, Professor	Study on time-domain-multiplexed 2D continuous-variable cluster states and its application to large-scale quantum information processing	FY2018-2022	145,100 489,200
18H05208	Shinya Koshihara 10192056	Tokyo Institute of Technology, School of Science, Professor	Development of novel photo-induced phase conversion materials based on quantum dynamics control of Charge-Structure-Spin-Photon coupled systems	FY2018-2022	118,000 484,700
18H05209	Eiji Yashima 50191101	Nagoya University, Graduate School of Engineering, Professor	Development of Ultimate Functions Based on Helical Polymers with Helicity Memory	FY2018-2022	131,700 457,300
18H05210	Mitsuhiro Nakamura 90183889	Nagoya University, Institute of Materials and Systems for Sustainability, Professor	Nuclear Emulsion - New deployments for fundamental and interdisciplinary researches in the 21st century -	FY2018-2022	36,500 455,400
18H05211	Akira Fujimaki 20183931	Nagoya University, Graduate School of Engineering, Professor	Research on ultra-low power sub-terahertz superconducting quantum digital systems based on pulse-driven circuits	FY2018-2022	107,700 473,400
18H05212	Yasufumi Fujiwara 10181421	Osaka University, Graduate School of Engineering, Professor	Development of semiconductor intra-center photonics	FY2018-2022	106,600 490,300

（3）Biological Sciences（3 Projects）　　（Thousands of Yen）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05213	Kaoru Inokuchi 20318827	University of Toyama, Graduate School of Medicine and Pharmaceutical Sciences, Professor	Mechanisms underlying Information processing in idling brain	FY2018-2022	77,000 427,200
18H05214	Hiroyuki Sasaki 30183825	Kyushu University, Medical Institute of Bioregulation, Professor	Omics approaches towards the elucidation of the molecular network regulating the developmental capacity of the mammalian oocyte	FY2018-2022	91,000 391,200
18H05215	Keiichi Nakayama 80291508	Kyushu University, Medical Institute of Bioregulation, Distinguished Professor	Investigation for mechanisms underlying cell cycle regulation and metabolism in stem cells	FY2018-2022	55,800 394,400

【Grant-in-Aid for Specially Promoted Research】

Humanities and Social Sciences

Title of Project : A Comprehensive Study of Life Course and Inequality Using the Framework of Cumulative Advantages and Disadvantages

Hiroshi Ishida
(The University of Tokyo, Institute of Social Science, Professor)

Research Project Number : 18H05204 Researcher Number : 40272504
Keyword : Inequality, life course, panel survey, quantitative analysis

【Purpose and Background of the Research】

Low wages, non-standard employment, and long working hours among young people are just a few examples identified as urgent social issues to be addressed in Japan. Unfavorable labor market conditions were suspected to be one reason for delayed marriages and declining birth rates. Inequality and economic gaps occupied the central location in social discourse in Japan.

The primary research question for this project is: how and why does social inequality persist and accumulate across individuals' life courses? Through compiling long-term panel surveys, the project aims (1) to identify diverse life course trajectories from youth to old age by taking into account multiple dimensions of the life course including education, employment, family, health, and attitudes as shown in Figure 1; and (2) to examine the process through which social inequality is generated and accumulated over those life course trajectories.

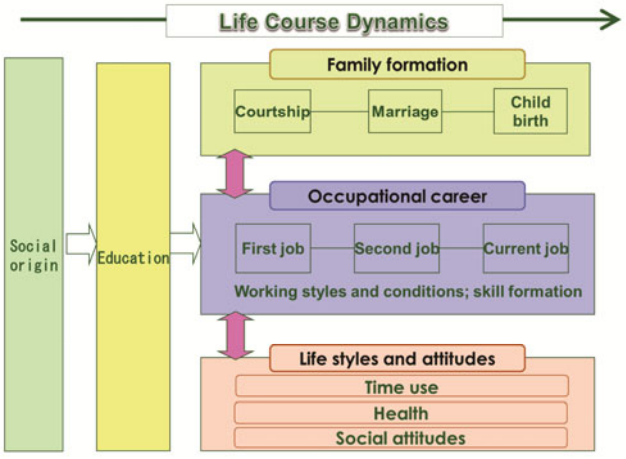


Figure 1 Life Course Dynamics

【Research Methods】

Our project has been successfully conducting the following surveys: a panel study targeted at the youth (20-34 years old) and the middle-aged (35-40 years old) since 2007; and a panel survey of the elderly (50-84 years old) since 2010. Our team will continue the data collection of the youth, the middle-age, and the old-age panel surveys. Our panel surveys allow us to identify diverse life course trajectories of individuals: those who were consistently disadvantaged from the initial life stage and those who were able to overcome their early disadvantages. Our project aims to identify the mechanisms enabling mobility out of and into the most disadvantaged positions and insights for breaking the cycle of cumulative disadvantages.

【Expected Research Achievements and Scientific Significance】

This study will identify the factors which explain differential life course trajectories and discover the mechanisms behind cumulative advantages and disadvantages. It takes into account various dimensions of life course trajectories: socio-economic career progression, family formation (marriage and childbirth), and health and subjective well-being. The study will also examine the reproduction of inequality across three generations.

The accumulated panel surveys are publically available for academic use and education. We have also been collaborating with other East Asian projects on the transition to adulthood. We will continue to work together and conduct cross-national studies on social inequality.

【Publications Relevant to the Project】

・H. Ishida (ed.) *Cumulative Advantage and Disadvantage and Youth 1: Education and Career*. Tokyo: Keiso Shobo, 2017 (in Japanese).
・H. Ishida & K. Sato (eds.) *Cumulative Advantage and Disadvantage and Youth 3: Life Design and Hope*. Tokyo: Keiso Shobo, 2017 (in Japanese).

【Term of Project】 FY2018-2024

【Budget Allocation】 470,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://csrda.iss.u-tokyo.ac.jp/en/panel/purpose/

Title of Project : Development and elucidation of highly efficient photoreaction systems using a strong coupling between nanocavity and plasmon

Hiroaki Misawa
(Hokkaido University, Research Institute for Electronic Science, Professor)

Research Project Number : 18H05205 Researcher Number : 30253230
Keyword : Plasmon, Nanoresonator, Strong coupling, Electron transfer, Photoemission electron microscopy

【Purpose and Background of the Research】

To realize a sustainable society, it is essential to develop innovative photochemical reaction systems that can efficiently utilize the abundant visible light contained in sunlight. We have elucidated that a titanium dioxide (TiO_2)/Au-film, which is a constituent element of the Au nanoparticle (Au-NPs)/TiO_2/Au-film electrode, becomes a nano-sized Fabry-Pérot (FP) resonator and that the nano-FP resonator is strongly coupled with the localized surface plasmon resonance (LSPR) of Au-NPs on TiO_2. We have also elucidated that the strongly coupled structure shows a large near-field enhancement in a wide wavelength range and a remarkable enhancement of the quantum yield in photoelectric conversion using water as an electron source compared with that with an uncoupled electrode. In this study, we aim to clarify the theory of plasmon-induced electron transfer and explore a strongly coupled electrode that enables further enhancement of the near-field and quantum yield.

【Research Methods】

To realize a plasmon-induced electron transfer reaction exhibiting a high quantum yield, the key steps are 1) to optimize strongly coupled electrodes and 2) to elucidate the plasmon-induced electron transfer reaction mechanism. Fig. 1a shows a strongly coupled electrode. The characteristic of this electrode is that its color changes from yellow to black due to strong light absorption with a wide wavelength in the visible range when Au-NPs are formed on the TiO_2/Au-fim (Fig. 1b). In this study, we derive the design of the nano-FP resonator and Au-NPs using electromagnetic simulations to achieve a larger near-field enhancement, in collaboration with Prof. Sasaki of Hokkaido University (Co-I). The strongly coupled electrode is fabricated by the obtained optimum structural design, and its spectral and photoelectric conversion properties are provided as feedback to the structural design.

In parallel with these studies, we promote research to elucidate the mechanism of plasmon-induced electron transfer. A laser pulse with a pulse duration of ~20 fs, a center wavelength of 800 nm as a fundamental wavelength (ω) and its third harmonic generation (3ω, 267 nm) are introduced into the existing photoemission electron microscopy (PEEM) via an optical delay system, and the time-resolved two-photon PEEM is constructed (Fig. 2a). LSPR is excited by ω to generate hot electrons, and these are further excited by 3ω to generate photoelectrons. By measuring the energy distribution of the electron, we investigate the energy distribution of the hot electrons and holes involved in the electron transfer reaction (Fig. 2b). The near-field spectrum, phase relaxation time, and electron transfer dynamics are also studied. Furthermore, we explore the intermediates of water oxidation by surface-enhanced Raman scattering spectroscopy and elucidate the mechanism of oxygen evolution, in collaboration with Prof. Murakoshi of Hokkaido University (Co-I).

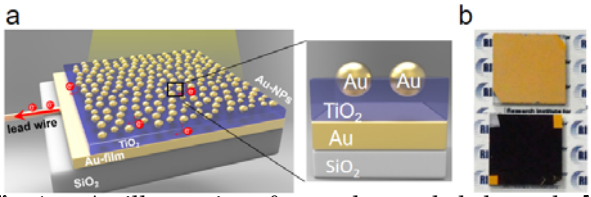


Fig. 1. a, An illustration of strongly-coupled electrode, **b**, Photographs of the TiO_2/Au-film (upper) and the strongly-coupled electrode (lower).

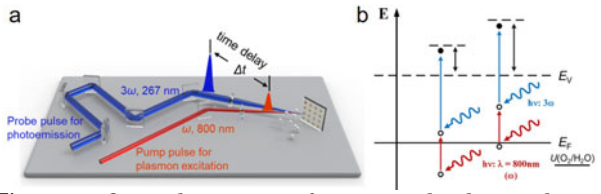


Fig. 2. a, Optical systems of time-resolved two-photon PEEM, **b**, Conceptual diagram of photoemission by 3ω.

【Expected Research Achievements and Scientific Significance】

The electron transfer reaction using a strongly coupled electrode can realize not only the efficient utilization of light but also a near-field enhancement in the entire visible region and an increase in the quantum yield of the reaction. It is expected to make great impacts in plasmon-induced solar energy conversion and photocatalytic studies. Moreover, it is possible to freely tune the wavelength at which the near-field enhancement is induced by selecting the size of the Au-NPs and the resonator length of the nano-FP resonator. Therefore, we believe that this technology induces a paradigm in shift not only plasmonic chemistry but also a wide range of other research fields, such as plasmonics, nanophotonics and spectroscopic research.

【Publications Relevant to the Project】

- H. Yu, Q. Sun, H. Misawa et al., "Exploring coupled plasmonic nanostructures in the near field by photoemission electron microscopy", *ACS Nano* **10**, 110373-10381 (2016).
- K. Ueno, T. Oshikiri, Q. Sun, X. Shi, H. Misawa, "Solid-state plasmonic solar cells", *Chem. Rev.* **118**, 2955-2993 (2018).

【Term of Project】 FY2018-2022

【Budget Allocation】 477,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://misawa.es.hokudai.ac.jp

Title of Project : High Energy Neutrino Universe explored by IceCube-Gen2

Shigeru Yoshida
(Chiba University, Graduate School of Science, Professor)

Research Project Number : 18H05206 Researcher Number : 00272518
Keyword : cosmic-ray, neutrinos, south pole, particle physics, astronomy

【Purpose and Background of the Research】

The IceCube Neutrino Observatory, the three-dimensional detector array deployed in the deep glacier at the South Pole, made the first discovery of high energy cosmic neutrinos in 2013 and pioneered the new frontier of observing our cosmos, High-Energy Neutrino Astronomy. Neutrinos are charge-neutral elementary particles which can travel over cosmological distances without losing their energies. They are unique messengers to reveal dynamically evolving ultra-high energy universe, which could not be explored by the conventional astro-messengers like optical photons. Taking this advantage further, IceCube started operating a realtime neutrino alert system in 2016: Identifying astrophysical neutrinos real-timely to deliver detection information to world-wide astronomical observation facilities for follow-ups. It realized the great achievement last year that the observation of a neutrino in directional and temporal coincidence with high energy γ-rays identified a neutrino emission object. This "multi-messenger astronomy" powers capability of probing energetic phenomena in cosmos and therefore it is critical to improve statistics of high energy neutrino events for multi-messenger campaigns.

【Research Methods】

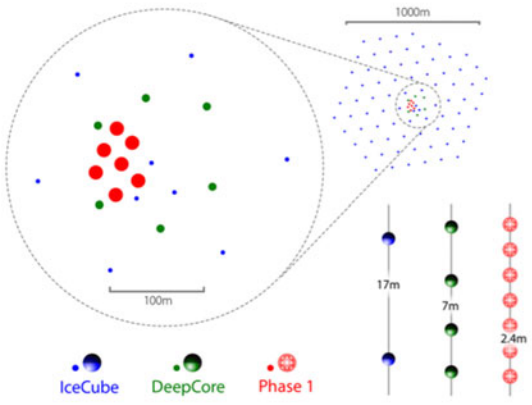


Figure 1. The concept of IceCube Upgrade

In order to greatly enhance the efficiency of high energy astrophysical neutrino detections, IceCube has planned the next generation project, IceCube-Gen2. As the phase 1 of this expansion, we upgrade IceCube facility by densely deploying the new optical detectors in the central area of the IceCube instrumentation volume.
The Japanese group has developed a new type of optical detectors, "D-Egg", which realize twice better photon detection efficiency than the present modules running in IceCube. We will deploy two hundred of D-Eggs down to the glacier ice. This upgrade is expected to improve accuracy in estimation of arrival directions of cosmic neutrinos. We also strengthen the radio detector array for seeking even higher energy neutrinos than ever detected. With this upgrade, we conduct a deeper survey of high energy universe by neutrinos in the wide energy band from TeV to EeV.

【Expected Research Achievements and Scientific Significance】

The upgrade is expected to reveal various objects to emit high energy neutrinos. Follow-up observations by radio, optical, X-rays, and γ-rays will bring us understanding of origin of ultra-high energy cosmic rays, the most energetic radiation in Universe. We also expect to discover neutrino-only luminous objects.

【Publications Relevant to the Project】

・ S.Yoshida et al, IceCube Collaboration, "Constraints on Ultrahigh-Energy Cosmic-Ray Sources from a Search for Neutrinos above 10 PeV with IceCube" Physical Review Letters **117** 141101 1-9 (2016)
・ S,Yoshida et al IceCube Collaboration "The IceCube realtime alert system", Astroparticle Physics **92** 30-41 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 411,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.icehap.chiba-u.jp

Title of Project : Study on time-domain-multiplexed 2D continuous-variable cluster states and its application to large-scale quantum information processing

Akira Furusawa
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05207 Researcher Number : 90332569
Keyword : Cluster states, Quantum entanglement, Quantum Computer

【Purpose and Background of the Research】

By using the technology of continuous-variable (CV) quantum teleportation, we will try to establish a methodology to build a large-scale optical quantum computer. Here, we succeeded in CV quantum teleportation for the very first time in the world and the technology has become a "world standard" in these days. Since we can build a large-scale quantum computer by combining quantum teleportation technology and a large-scale 2D entangled state (cluster state), we will try to create a large-scale 2D CV cluster state by time-domain multiplexing and will establish a methodology how to use it with CV quantum teleportation technology to build a large-scale optical quantum computer. Here, we also developed the technology of time-domain multiplexing.

【Research Methods】

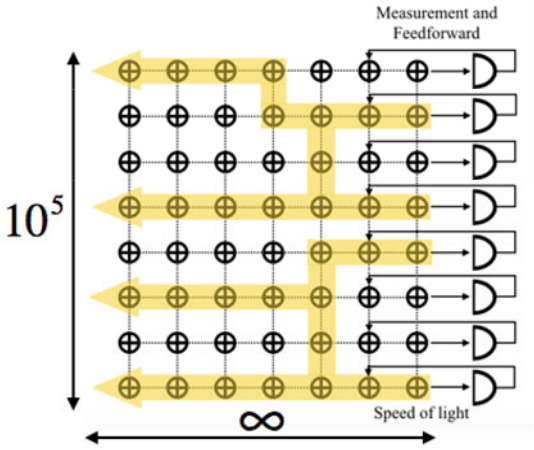


Fig. 1 Large-scale quantum computing with time-domain multiplexing.

By using a large-scale 2D cluster state, we can make a large-scale universal quantum computer as shown in Fig.1. Here a large-scale 2D cluster state corresponds to a superposition of all possible quantum computing patterns. We can select one of them by changing the measurement bases and can make a collapse of the cluster state to the desired state, which is the output of the quantum computer. The randomness of the measurement results can be eliminated by operations depending on the measurement results, which is called "feedforward". The whole process is called "one-way quantum computing", because a measurement process is irreversible.

This type of large-scale 2D cluster states can be created only by using four squeezed vacua, five beam splitters, and two delay lines as shown in Fig. 2. We will realize the large-scale 2D cluster states by using this methodology.

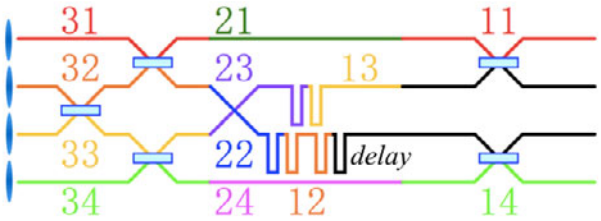


Fig. 2 Schematic of experimental setup for the creation of large-scale 2D cluster states.

【Expected Research Achievements and Scientific Significance】

We will show that our methodology works well for building a large-scale universal quantum computer.

【Publications Relevant to the Project】

・A. Furusawa et al., Science **282**, 706 (1998)
・N. Lee et al., Science **332**, 330 (2011)
・H. Yonezawa et al., Science **337**, 1514 (2012)
・S. Yokoyama et al., Nature Photonics **7**, 982 (2013)
・S. Takeda et al., Nature **500**, 315 (2013)

【Term of Project】 FY2018-2022

【Budget Allocation】 489,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://alice.t.u-tokyo.ac.jp

【Grant-in-Aid for Specially Promoted Research】

Science and Engineering

Title of Project : Development of novel photo-induced phase conversion materials based on quantum dynamic control of Charge-Structure-Spin-Photon coupled systems

Shinya Koshihara
(Tokyo Institute of Technology, School of Science, Professor)

Research Project Number : 18H05208 Researcher Number : 10192056
Keyword : Optical Properties of Materials, Photoinduced Phase Transition, Ultrafast Structural Dynamics

【Purpose and Background of the Research】

An attractive target for materials science is to achieve control of phase transitions using light (photo-induced phase transitions: PIPTs). To date, PIPT dynamics has been governed by the slow relaxation/dissipation of photo-injected energy leading to decoherence of the multi-electron state in a cooperatively interacting system (classical PIPT). Utilization of the quantum dynamics of a multi-electron state (quantum PIPT) that is coherently and strongly coupled to the electromagnetic field of the excitation photon itself is essential for creating photonic phase-switching materials with ultrahigh speeds and sensitive responses. Combining ultrafast modifications of three main physical degrees of freedom in solids (Charge-Structure-Spin, C-S-S) within the vibrational periods of elementary excitations will enable us to find unique C-S-S-ordered states, which can be obtained only by quantum PIPT (i.e., quantum hidden states: QHS).

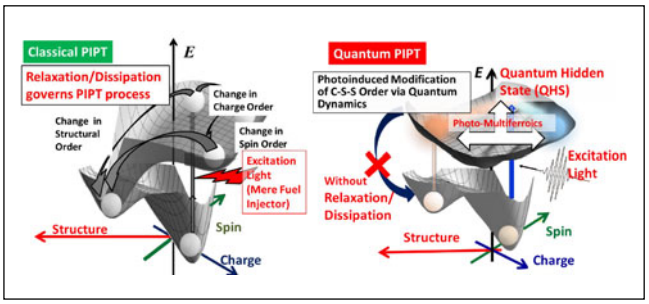


Figure 1 Illustration of classical PIPT dynamics (left-hand side) and quantum PIPT (right-hand side)

【Research Methods】

To clarify the ultrafast C-S-S coupled dynamics in a quantum PIPT system and develop new materials, this project establishes the following three teams and involves deep collaborations among materials scientists, specialists in ultrafast spectroscopy/ electron diffraction, and theoreticians:

Team 1: Search and develop candidate materials that show QHS *via* ultrafast quantum PIPT based on the strong coupling among C-S-S freedoms.

Team 2: Construct an ultrashort (30 fs) pulsed electron-diffraction facility with a spin-polarized /depolarized electron source.

Team 3: Construct a theoretical framework for quantum PIPT.

【Expected Research Achievements and Scientific Significance】

In this project, a pulsed electron-diffraction system with a 30-fs width, combined with a spin-polarized electron source will be constructed to enable observations of ultrafast C-S-S dynamics. The combined use of this system and an ultrafast spectroscopic probe will reveal the quantum natures of the microscopic mechanisms driving the initial PIPT process. The accumulated knowledge will unveil a realistic manner for photo-controlling the sensitive and ultrafast changes in magnetic, electronic, optical, dielectric, and structural properties of materials based on C-S-S strong coupling *via* QHS (photo-multiferroics). This research will have a large impact on the general field of photo-functional materials while opening the door for photonic and quantum control of a wide class of materials with ultrahigh speeds.

【Publications Relevant to the Project】

・"Direct Observation of Collective Modes Coupled to Molecular Orbital Driven Charge Transfer", T.Ishikawa, M.Hada, *R.J.D. Miller, K.Onda, S.Koshihara, et al. Science 350, pp.1501 (2015)
・"Coherent dynamics of photoinduced phase formation in a strongly correlated organic crystal", T.Ishikawa, S.Koshihara, *K.Onda et al. Phys. Rev. B 89, 161102(R) (2014)

【Term of Project】 FY2018-2022

【Budget Allocation】 484,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.chemistry.titech.ac.jp/~koshihara/english2/index.html

Title of Project : Development of Ultimate Functions Based on Helical Polymers with Helicity Memory

Eiji Yashima
(Nagoya University, Graduate School of Engineering, Professor)

Research Project Number : 18H05209 Researcher Number : 50191101
Keyword : Helical polymer, helical structure, chirality, asymmetric catalysis, chiral separation

【Purpose and Background of the Research】

Mother nature applies the one-handed helical structure in biological systems at the macromolecular and supramolecular levels, which links to their sophisticated functions. Chemists have been challenged to develop artificial helices to mimic such biological helices and functions. Apart from the previous studies, the present project aims to develop ultimate functions based on synthetic helical polymers with a unique "static memory of helicity" that cannot be achieved by the biological helical systems. Our helical polymers possess outstanding exclusive features, such as (1) remarkable chiral amplification of the helical chirality, (2) ultrafast helicity induction and subsequent memory of the helicity, (3) spring-like motion accompanied by a significant visible and fluorescence color change, (4) flexible and adaptable helical cavity, and (5) easy modification of the pendant groups. With these key features in hand, we will establish rational strategies for developing helical polymers with a unique static memory of the helicity and then develop [1] an ultimate chirality detection system for the extremely small chirality, [2] practically useful switchable chiral stationary phases (CSPs) for HPLC and asymmetric catalysts, [3] an in-situ colorimetric/fluorescence sensing system, and [4] enantioseparation and asymmetric catalysis within a helical cavity of the helical polymers.

【Research Methods】

Taking advantage of the outstanding features of the helical polymers with the static helicity memory, the structure-property relationships of the helical polymers will be explored to realize the ultimate functions. The unique and versatile static helicity memory strategy makes it possible to further modify the side groups with the desired functional groups, while maintaining their static helicity memory, leading to the developments of the ultimate functions.

【Expected Research Achievements and Scientific Significance】

While a huge number of studies on helical systems have been reported, our helical polymers are unique and exclusive among those prepared before because of their unique static memory of the helicity with a remarkable amplification of the helical chirality. Therefore, making the best use of our helical polymers enables to develop innovative chiral materials with specific functions that cannot be achieved by the biological helical systems. The fundamental knowledge gained from this project will also contribute to understanding the origin of the biomolecular homochirality.

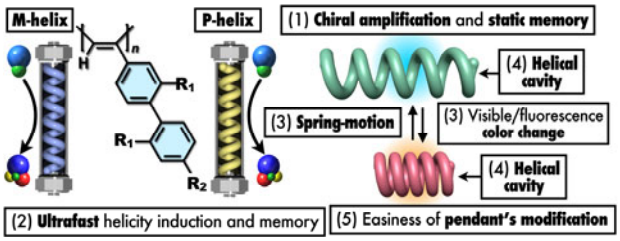


Figure Outstanding properties of helical polymers with a static memory of helicity.

【Publications Relevant to the Project】

・E. Yashima, N. Ousaka, D. Taura, K. Shimomura, T. Ikai, K. Maeda, Supramolecular Helical Systems: Helical Assemblies of Small Molecules, Foldamers, and Polymers with Chiral Amplification and Their Functions, *Chem. Rev.* **116**, 13752-13990 (2016).
・K. Shimomura, T. Ikai, S. Kanoh, E. Yashima, K. Maeda, Switchable Enantioseparation Based on Macromolecular Memory of a Helical Polyacetylene in the Solid State, *Nature Chem.* **6**, 429-434 (2014).

【Term of Project】 FY2018-2022

【Budget Allocation】 457,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://helix.mol.nagoya-u.ac.jp/e/index.html
yashima@chembio.nagoya-u.ac.jp

Title of Project : Nuclear Emulsion - New deployments for fundamental and interdisciplinary researches in the 21st century -

Mitsuhiro Nakamura
(Nagoya University, Institute of Materials and Systems for Sustainability, Professor)

Research Project Number : 18H05210 Researcher Number : 90183889
Keyword : Nuclear Emulsion. elementary particle physics, Astronomy, Muon radiography

【Purpose and Background of the Research】

Nuclear Emulsion, which has a history of about 100 years, is still contributing to the progress in elementary particle physics by the discovery of Tau-neutrino and the discovery of Tau-neutrino appearance in neutrino oscillation. Adding to those, applications to interdisciplinary researches are rapidly extending. Examples are Muon radiography (e.g. discovery of a big void in Khufu Pyramid) and balloon born large aperture Gamma-ray telescope.

Those movements are realized by fully automated nuclear emulsion read-out system developed by us and the lab-made nuclear emulsion also developed by us from 2010. The latter has a meaning to take back still-worth technical resources from the company to the university dealing with the market shrinkage, and to give additional values through new developments.

In this research project, we will develop an automated nuclear emulsion read-out system which has ~40times faster scanning speed than the current system, a nuclear emulsion film production system which can deal with 10000m²/year and adding new features to nuclear emulsion. Those developments will push forward strongly the currently running and coming researches in the region of fundamental and interdisciplinary researches.

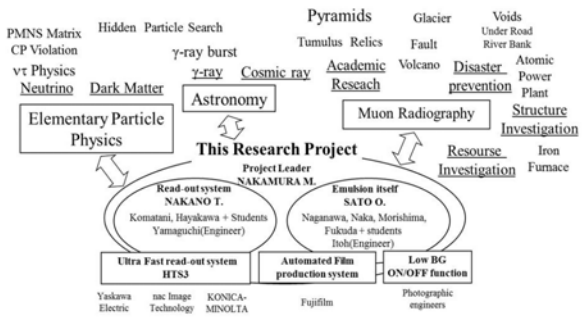


Fig1. This research project and the related research regions.

【Research Methods】

① R&D of 40times faster read-out system by adopting slant optics.
② R&D of automated emulsion film production systems to deal with 10000m²/year level request.
③ Preparation of the gel production recipe database to give the best solution to a specified purpose. Realization of low background nuclear emulsion and sensitivity ON/OFF function.

【Expected Research Achievements and Scientific Significance】

In the field of elementary particle physics, application to interdisciplinary research region becomes important in parallel with the search for the phenomena beyond the established standard model. As we have nothing in the energy frontier until today. We must extend the frontier to any possible directions, neutrino research at where the first break of the standard model was found, the intensity frontier to explore the hidden sectors. Also dark matter is the subject beyond the standard model. NINJA@JPARC, DsTAU & SHiP@CERN and NEWSdm@LNGS are the related emulsion projects.

Relating to the application, discovery of new structures in Khufu Pyramid by muon radiography shows how the technologies developed for particle physics can shed new light on the interdisciplinary field. In the region of astronomy, nuclear emulsion can realize a balloon born γ ray telescope with 10times larger aperture and one order finer resolution than Fermi satellite.

In those interdisciplinary researches, repeat of "try and error" is very important. Nuclear emulsion can lower the barrier of "try and error", by its low cost, easily accessible tools for detector production and analysis. Also its scalability will allow easy project extension.

The outputs from this research project will become a powerful motive force to push forward the fundamental & interdisciplinary researches.

【Publications Relevant to the Project】

・"Expanding Horizon of the Nuclear Emulsion Applications", Journal of the Society of Photographic Science and Technology of Japan, Vol 71, No5, 2008 (in Japanese).

【Term of Project】

FY2018-2022

【Budget Allocation】

455,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://flab.phys.nagoya-u.ac.jp/2011/

Title of Project : Research on ultra-low power sub-terahertz superconducting quantum digital systems based on pulse-driven circuits

Akira Fujimaki
(Nagoya University, Graduate School of Engineering, Professor)

Research Project Number : 18H05211 Researcher Number : 20183931
Keyword : single flux quantum, half flux quantum, magnetic Josephson junction

【Purpose and Background of the Research】

Our social life has been changing with the extensive spread of the digital technologies such as the internet, AI. While convenience is improved remarkably, energy- efficient digital technology is needed for supporting the improvement.

Impulses with widths of a few pico seconds are used as an information carrier in the superconductor single flux quantum (SFQ) circuit. The SFQ circuits are relieved of the recharge process that hampers speed-up and reduced power consumption in semiconductor integrated circuits (ICs). The SFQ ICs have been expected to operate around 100 GHz with very high energy-efficiency.

However, matrix memories proposed so far require recharge process even in the SFQ circuit. In this study, we will develop matrix memories driven by an impulse based on the half flux quantum (HFQ) circuit. We can reduce the energy required for the transition between the two stable states in the HFQ circuit by introducing magnetic Josephson junctions (MJJs). The elementary unit of the HFQ circuit is almost the same as that of flux qubits. This means our technology has high affinity to the qubits, so that we can unify the SFQ/HFQ circuits with the quantum computers in the future.

【Research Methods】

πSQUIDs composed of a π MJJ and a 0JJ play an important role in the HFQ circuits. Here, the initial phase difference of a π MJJ is shifted by π, while conventional JJ (0JJ) has no phase shift.

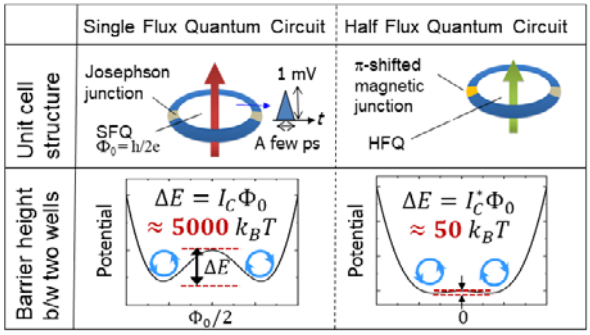


Figure 1 Unit cell structures and potential shapes in the SFQ/HFQ circuits

The barrier height between the two states in the HFQ circuits is about 1/100 compared to that of the SFQ circuits as shown in Figure 1. In addition, the bi-stable stable states are achieved without any applied field in the HFQ circuits. These lead to extremely-energy efficient circuits.

【Expected Research Achievements and Scientific Significance】

We will achieve an SFQ microprocessor operating around 100 GHz and a pulse-driven HSQ-based matrix memory. We will also demonstrate a digital system by combining both circuits.

Ultimately fast operations are expected by using πSQUIDs. We will try to obtain information about the relationship between the uncertainty principle and the classical computation through this experiment. In future, we will combine the SFQ/HFQ technology and the quantum computers.

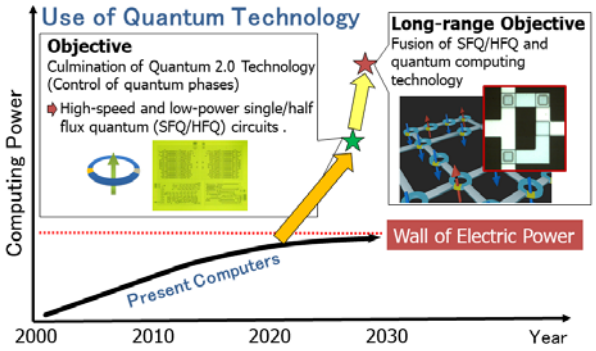


Figure 2 Roadmap of the technology

【Publications Relevant to the Project】

・T. Kamiya, M. Tanaka, A. Fujimaki, et al., IEICE Trans. Electron., E101-C(5), pp.385-390, 2018.

【Term of Project】 FY2018-2022

【Budget Allocation】 473,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.super.nuee.nagoya-u.ac.jp/tokusui/

Title of Project : Development of semiconductors intra-center photonics

Yasufumi Fujiwara
(Osaka University, Graduate School of Engineering, Professor)

Research Project Number : 18H05212 Researcher Number : 10181421
Keyword : Semiconductor, Thin films, Optical properties of condensed matter, Optical devices

【Purpose and Background of the Research】

Our surroundings are full of various light sources, which are produced from semiconductors. These lights use transitions that occur between the conduction band and the valence band of the semiconductor, which is referred to as interband photonics. However, this application has critical problems, which lie at the heart of the light emission principle known as Fermi's Golden Rule.

We have worked on the development of semiconductors intra-center photonics. This novel photonics uses the intra-4*f* shell transitions of rare-earth (RE) ions doped in semiconductors. In 2009, we invented a narrow-band red light-emitting diode (LED) using Eu-doped GaN (GaN:Eu). Due to optimization of the device processing, the output power of the LED has been increasing steadily to over 1 mW.

In this project, we move to the next and final step for the development of the GaN:Eu red LED (Fig. 1). We will further enhance the output parameters by intentional manipulation of the radiative recombination probability at the atomic level of the Eu ions, which will be achieved through control of their photon fields using micro- and nano-cavities. Subsequently, we will extend this approach to other RE ions for the realization of a RE-based full-color high-resolution display with exceptional characteristics.

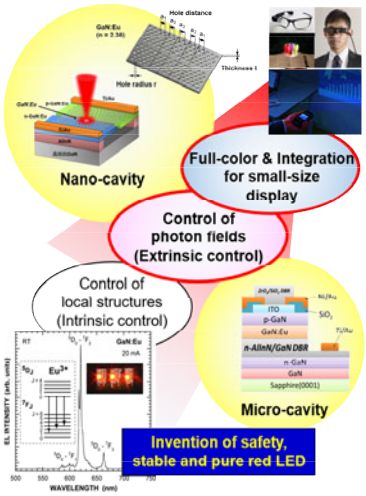


Fig. 1 Contents and flow of this research project

【Research Methods】

(1) Fabrication of micro- and nano-cavities using GaN:Eu, and the characterization of newly emerging Eu intra-4*f* shell luminescence properties under optical pumping in a cavity that has a sufficiently high Q factor.
(2) Fabrication of a LED structure using GaN:Eu with the cavities. The unique luminescence properties will be investigated under current injection.
(3) Extension of the research to Tm- or Er-doped nitride semiconductors to realize a new family of LEDs that operate in the blue and green emission range. Finally, these red, green and blue LEDs will be integrated on the same substrate to demonstrate the feasibility of a monolithic full-color LED display.

【Expected Research Achievements and Scientific Significance】

Research on RE-doped materials has been based on experience obtained through trial and error, not on material design by the precise control of RE doping and an understanding of the energy-transfer mechanisms. This project will provide guiding principles to design RE-doped materials with "made to order" optical characteristics.

【Publications Relevant to the Project】

・B. Mitchell, Y. Fujiwara *et al.*: "Perspective: Highly efficient GaN-based red LEDs using europium doping," Journal of Applied Physics **123** (2018) pp. 160901/1-12.
・B. Mitchell, Y. Fujiwara *et al.*: "Utilization of native oxygen in Eu(RE)-doped GaN for enabling device compatibility in optoelectronic applications," Scientific Reports **6** (2016) pp. 18808/1-8.

【Term of Project】 FY2018-2022

【Budget Allocation】 490,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.mat.eng.osaka-u.ac.jp/mse6/

Title of Project : Mechanisms underlying information processing in idling brain

Kaoru Inokuchi
(University of Toyama, Graduate School of Medicine and Pharmaceutical Sciences, Professor)

Research Project Number : 18H05213 Researcher Number : 20318827
Keyword : neuroscience, idling brain, memory engram, sleep, replay

【Purpose and Background of the Research】

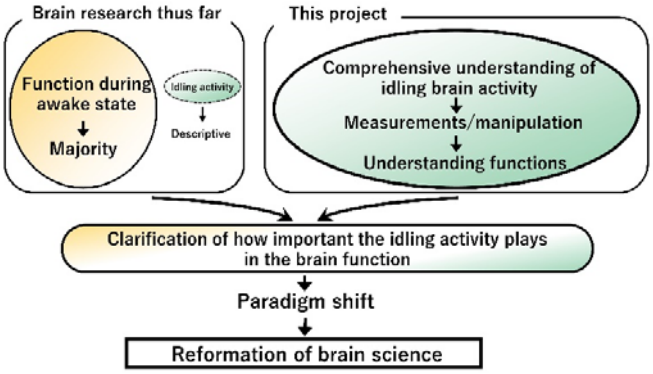
Recently it has been clarified that neurons in the brain are active even when animals sleep or rest, denoted in this proposal as "idling brain state". Everybody has experiences where they suddenly get the answer on an unsolved issue after sleep or relaxation. We have recently found in mice that, among a number of cell assemblies that were activated during hippocampus-dependent learning, only cell assemblies that were reactivated during subsequent sleep (replay) were again activated during the subsequent retrieval session. These suggest strongly that idling activity of the brain plays important roles in information processing than previously thought. In this research project, we aim to clarify and characterize the cell assembly activities during idling state by means of live-calcium imaging with microendoscope. We will further clarify the functions of idling brain activities.

【Research Methods】

We will employ micro-endoscopes, nVista and nVoke, and in vivo calcium imaging with GCaMP to monitor neuronal activity in the brain during pre-learning idling state, learning, post-learning idling state, and retrieval. We will perform a series of experiments in which we will manipulate the activity of selected cell assemblies to elucidate the roles of idling activity. We will clarify 1) how memories are represented as cell assemblies during idling state, 2) how distinct memories are checked and integrated, if necessary, to create a new memory, 3) roles played by idling activity in the consolidation, selection, association, and dissociation of memories.

【Expected Research Achievements and Scientific Significance】

This work will not only reveal the idling activity at the cell assembly level, but also elucidate the functional role of the idling activity in information processing by employing cutting-edge techniques. Thus, this work will clarify latent abilities of the brain based on the scientific background. This work would have an impact on the brain science as well as a wide variety of sciences and arts.



【Publications Relevant to the Project】

1. Abdou, K, ……, and Inokuchi, K. Synapse-specific representation of the identity of overlapping memory engrams. ***Science*** 360: 1227-1231 (2018)
2. Yokose J, ….., and Inokuchi K. Overlapping memory trace indispensable for linking, but not recalling, individual memories. ***Science*** 355: 398-403 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 427,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.med.u-toyama.ac.jp/bmb/index-j.html
bmb@med.u-toyama.ac.jp

Title of Project : Omics approaches towards the elucidation of the molecular network regulating the developmental capacity of the mammalian oocyte

Hiroyuki Sasaki
(Kyushu University, Medical Institute of Bioregulation, Professor)

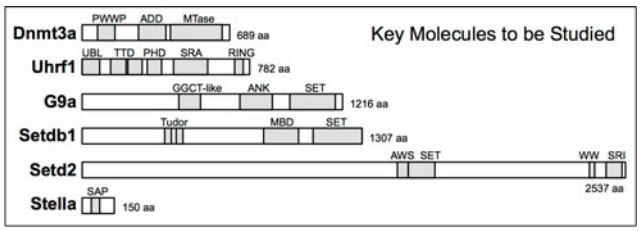
Research Project Number : 18H05214 Researcher Number : 30183825
Keyword : Oocyte, Omics, Epigenome, Genome editing, Machine learning

【Purpose and Background of the Research】

The oocyte is a female gametocyte essential for animal reproduction. It possesses essentially all information necessary to support development of an entire animal body (developmental program), but the molecular networks involved in the establishment and/or maintenance of the program are poorly understood. In this project, we study the roles of putative components of the networks in mouse oocyte and identify new components and associated factors using genome editing and multi-omics analyses. We focus on the repressive epigenetic program that is established in the oocyte and involved in silencing of tissue-specific genes, retrotransposons, and non-expressed alleles of imprinted genes in early embryo. Furthermore, we develop models to predict the heritability/reprogrammability of the program and of errors that occur to it. Our study provides the basis for better understanding of mammalian development and epigenetic inheritance.

【Research Methods】

Six key epigenetic factors that are potentially involved in the networks are studied: a DNA methyltransferase (Dnmt3a), a hemimethylated CG biding E3 ubiquitin ligase (Uhrf1), histone methyltransferases (G9a, Setdb1, Setd2), and a factor protecting 5mC from oxidation (Stella). We generate mice mutated for the respective genes by genome editing, perform micro-scale multi-omics analyses, and infer the regulatory networks responsible for the repressive program. If necessary, we introduce amino acid changes in specific protein domains of these factors. Embryological and cytological techniques are used to dissect the developmental phenotypes of the mutants. We also identify new components of the networks and their associated factors by, for example, proteomics approaches. Machine learning is performed to train models to predict the methylated/unmethylated state of a DNA region of interest in oocyte and early embryo and heritability/reprogrammability of the modifications. By integrating the results from all studies, we will try to resolve the regulatory networks involving histone modifications and DNA methylation and understand how epigenetic inheritance occurs.



【Expected Research Achievements and Scientific Significance】

We expect that this research project will reveal both expected and unexpected functions of the factors potentially involved in the establishment and/or maintenance of the repressive program and resolve the regulatory networks. The outcome of this study will have impact on the studies of infertility, assisted reproduction technology, pluripotent stem cells, livestock breeding, and inheritance of environmentally induced epigenetic changes.

【Publications Relevant to the Project】

・Kaneda, M. et al. Essential role for *de novo* DNA methyltransferase Dnmt3a in paternal and maternal imprinting. *Nature* 429, 900-903 (2004).
・Watanabe, T. et al. Endogenous siRNAs from naturally formed dsRNAs regulate transcripts in mouse oocytes. *Nature* 453, 539-543 (2008).
・Maenohara, S. et al. Role of UHRF1 in de novo DNA methylation in oocytes and maintenance methylation in preimplantation embryos. *PLoS Genet.* 13, e1007042 (2017).

【Term of Project】

FY2018-2022

【Budget Allocation】

391,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.bioreg.kyushu-u.ac.jp/labo/epigenome/

Title of Project : Investigation for mechanisms underlying cell cycle regulation and metabolism in stem cells

Keiichi Nakayama
(Kyushu University, Medical Institute of Bioregulation, Distinguished Professor)

Research Project Number : 18H05215 Researcher Number : 80291508
Keyword : Stem cell, Cell cycle, Metabolism

【Purpose and Background of the Research】

The cell cycle in adult stem cells (ASCs) is arrested, and therefore regeneration of nerves and cardiomyocytes after injury is limited. Understanding the mechanism underlying cell cycle arrest will lead to the development of strategies for tissue regeneration. In contrast, embryonic stem cells (ESCs) proliferate rapidly. We have recently discovered that this difference is attributable to the expression of CDK inhibitor p57 and ubiquitin ligase component Skp2.

The aims of this study are 1) to decipher the mechanisms underlying transcriptional regulation of p57 and Skp2 genes in ASCs and ESCs, 2) to identify the molecular connection between cell cycle and metabolism by the next-generation proteomics, and 3) to develop new methods to reactivate cell cycle in ASCs for tissue regeneration after injury.

【Research Methods】

In this study, we will elucidate the mechanism underlying transcriptional regulation of p57 and Skp2 genes in stem cells. Transacting factors identified will be ablated in mice to examine the biological significance of these factors. Furthermore, the next-generation proteomics platform termed iMPAQT (Fig. 1) will be applied to delineate the entire landscape of metabolic pathways in ASCs and ESCs, which will lead to identification of molecules connecting cell cycle and metabolism.

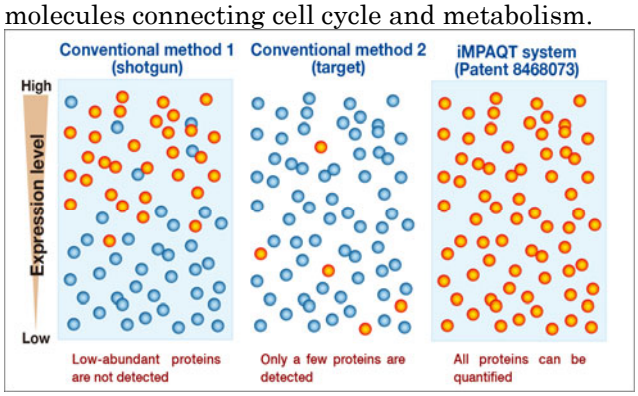


Fig. 1 iMPAQT system can measure all proteins

【Expected Research Achievements and Scientific Significance】

Elucidation of the mechanism for cell cycle arrest in ASCs and identification of key molecules are expected to promote development of new strategies for tissue regeneration after injury by cerebrovascular disorder, neurodegenerative diseases, ischemic heart disease, hepatic cirrhosis, and other diseases. In contrast, cell cycle activation by targeting p57 might promote proliferation of cancer stem cells (CSCs), which can sensitize them to anticancer drugs (Fig. 2).

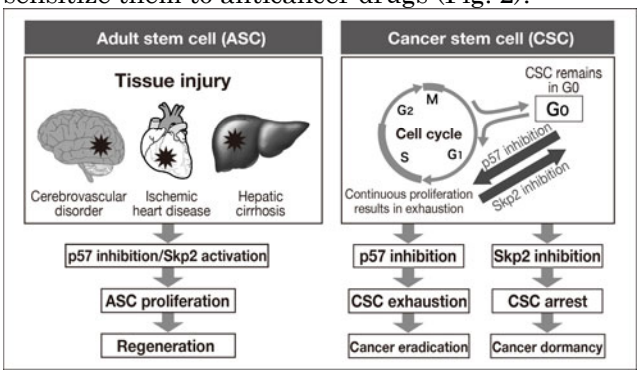


Fig. 2 Expected research achievements

【Publications Relevant to the Project】

・Matsumoto, M., et al., Nakayama, K., Nakayama, K.I.: A large-scale targeted proteomics assay resource based on an in vitro human proteome. ***Nature Methods*** 14: 251-258 (2017).
・Takeishi, S., et al., Nakayama, K.I.: Ablation of Fbxw7 eliminates leukemia-initiating cells by preventing quiescence. ***Cancer Cell*** 23: 347-361 (2013).

【Term of Project】 FY2018-2022

【Budget Allocation】 394,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.bioreg.kyushu-u.ac.jp/saibou/index.html

List of the Continuing Projects for Grant-in-Aid for Specially Promoted Research of KAKENHI

Humanities and Social Sciences（ 4 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26000001	Shunsuke Managi 70372456	Kyushu University, Faculty of Engineering, Professor	An Economic Analysis of Sustainable Development in a New era with Decreasing Population and Large-scale Negative Shock to the Economy	FY2014-2018	335,500
15H05692	Hidehiko Ichimura 50401196	The University of Tokyo, Graduate School of Economics, Professor	Construction of Policy-Evaluation-Oriented and Heterogeneity-Sensitive National Transfer Accounts and their Application to Policies for Coping with Declining Fertility and Population Aging	FY2015-2019	417,100
16H06283	Tetsuro Matsuzawa 60111986	Kyoto University, Institute for Advanced Study, Distinguished Professor	Primate foundation of language and altruism	FY2016-2020	361,200
17H06086	Yoshio Higuchi 20119001	Keio University, Faculty of Business and Commerce, Project Professor	Economic disparity and intergenerational transfer in the longevity society: Policy evaluation analysis using panel data	FY2017-2021	428,700

Science and Engineering（ 37 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26000002	Ryota Hino 00241521	Tohoku University, Graduate School of Science, Professor	Uncover processes of slips-to-the-trench, their past and present	FY2014-2018	426,100
26000003	Masayuki Nakahata 70192672	The University of Tokyo, Institute for Cosmic Ray Research, Professor	Observation of supernova neutrinos with neutron tagging	FY2014-2018	453,400
26000004	Toshinori Mori 90220011	The University of Tokyo, International Center for Elementary Particle Physics, Professor	MEG II Experiment - Highest Sensitivity Search for Rare Muon Decay to Explore Grand Unified Theories	FY2014-2018	425,100
26000005	Takaaki Kajita 40185773	The University of Tokyo, Institute for Cosmic Ray Research, Professor	Detection of gravitational waves with a cryogenic interferometer	FY2014-2018	446,800
26000006	Katsuya Shimizu 70283736	Osaka University, Graduate School of Engineering Science, Professor	Material Sciences at Very High Pressure: Frontier of Mbar Chemistry	FY2014-2018	359,500
26000007	Kazuhiko Nakatani 70237303	Osaka University, The Institute of Scientific and Industrial Research, Professor	Chemical Biology Studies on Trinucleotide Repeat Disease using Repeat-Binding Molecules	FY2014-2018	303,400
26000008	Seiji Ogo 60290904	Kyushu University, Graduate School of Engineering, Professor	New Energy Sources from Hydrogenase-Photosynthesis Models	FY2014-2018	437,900
26000009	Masataka Nakazawa 80333889	Tohoku University, Research Institute of Electrical Communication, Distinguished Professor	Proposal of multi-functional coherent Nyquist pulse and its ultrahigh-speed and highly-efficient optical transmission	FY2014-2018	436,600
26000010	Yoshiaki Nakano 50183885	The University of Tokyo, Graduate School of Engineering, Professor	Research on reconfigurable unitary optical mode converters and wavefront synthesizers using semiconductor photonic integrated circuits	FY2014-2018	434,000
26000011	Satoshi Kawata 30144439	Serendip Research, Chief Scientist	Molecular imaging of living cells with metallic nanoparticles	FY2014-2018	401,600

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05693	Hiroyuki Sagawa 80178590	The University of Tokyo, Institute for Cosmic Ray Research, Professor	Extended Telescope Array Experiment - Nearby Extreme Universe Elucidated by Highest-energy Cosmic Rays	FY2015-2019	447,100
15H05694	Yasuo Fukui 30135298	Nagoya University, Graduate School of Science, Designated Professor	Innovation of the “interstellar medium” by accurate measurements of the interstellar hydrogen	FY2015-2019	424,200
15H05695	Akira Tsuchiyama 90180017	Kyoto University, Graduate School of Science, Professor	A model for formation and evolution of solid materials in space based on 3D structures of solar primitive materials	FY2015-2019	394,900
15H05696	Kaoru Yamanouchi 40182597	The University of Tokyo, Graduate School of Science, Professor	Sub-femtosecond molecular imaging	FY2015-2019	399,600
15H05697	Shin-ichi Ohkoshi 10280801	The University of Tokyo, Graduate School of Science, Professor	Design of light- or electromagnetic-wave-correlating phase transition materials and research of their advanced functionalities	FY2015-2019	374,700
15H05698	Shu Kobayashi 50195781	The University of Tokyo, Graduate School of Science, Professor	Revolutionizing organic chemistry by utilizing water as solvent	FY2015-2019	421,200
15H05699	Junsaku Nitta 00393778	Tohoku University, Graduate School of Engineering, Professor	Spin-orbit Engineering	FY2015-2019	445,800
15H05700	Yasuhiko Arakawa 30134638	The University of Tokyo, Institute for Nano Quantum Information Electronics, Director	Solid-state Quantum Electrodynamics in Quantum Dot-Nanocavity Multiply-Coupled Quantum Systems and Its Application to Novel Light Sources	FY2015-2019	399,500
15H05701	Atsuo Yamada 30359690	The University of Tokyo, Graduate School of Engineering, Professor	Development of advanced energy storage system based on overall strategies on new materials and new interface	FY2015-2019	437,100
15H05702	Teruo Ono 90296749	Kyoto University, Institute for Chemical Research, Professor	Spin-orbitronics and device application	FY2015-2019	432,500
16H06284	Hidetoshi Katori 30233836	The University of Tokyo, Graduate School of Engineering, Professor	Investigation of novel engineering and scientific applications of ultra-precise optical lattice clocks	FY2016-2020	452,600
16H06285	Kei Hirose 50270921	The University of Tokyo, Graduate School of Science, Professor	Behaviour of liquids under high pressure and the early evolution of the Earth	FY2016-2020	387,500
16H06286	Kazuo Shiokawa 80226092	Nagoya University, Institute for Space-Earth Environmental Research, Professor	Study of dynamical variation of particles and waves in the inner magnetosphere using ground-based network observations	FY2016-2020	376,100
16H06287	Takahiro Sumi 30432214	Osaka University, Graduate School of Science, Professor	Search for cold exoplanets and free-floating planets by near infrared gravitational microlensing observation	FY2016-2020	450,400
16H06288	Takashi Kobayashi 70291317	High Energy Accelerator Research Organization, Institute of Particle and Nuclear Studies, Professor	Measurement of CP symmetry of neutrino by upgrading T2K experiment	FY2016-2020	418,600
16H06289	Kenji Ohmori 10241580	National Institutes of Natural Sciences, Institute for Molecular Science, Professor	Addressing Quantum Many-Body Dynamics by Ultrafast Coherent Control with Attosecond Precision	FY2016-2020	426,400
16H06290	Yukishige Ito 80168385	RIKEN, Synthetic Cellular Chemistry Laboratory, Chief Scientist	Chemical Biology of ER Related Glycan Modifications	FY2016-2020	319,400
16H06291	Taikan Oki 50221148	The University of Tokyo, Institute of Industrial Science, Professor	New frontiers in global hydrology	FY2016-2020	340,700

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
16H06292	Masahiro Asada 30167887	Tokyo Institute of Technology, Institute of Innovative Research, Professor	High-performance semiconductor terahertz devices unifying quantum transition and traveling of electrons	FY2016-2020	413,700
16H06293	Tatsumi Ishihara 80184555	Kyushu University, Graduate School of Engineering, Professor	Creation of Novel High Performance Catalyst Tailored by Chemo-mechanical Effects	FY2016-2020	380,700
17H06087	Naoki Watanabe 50271531	Hokkaido University, Institute of Low Temperature Science, Professor	Chemical evolution on cosmic dust: approach from elementary processes	FY2017-2021	433,900
17H06088	Hidemi Shigekawa 20134489	University of Tsukuba, Faculty of Pure and Applied Sciences, Professor	Development of sub-cycle time-resolved STM and its applications	FY2017-2021	453,600
17H06089	Akihide Fujisawa 60222262	Kyushu University, Research Institute for Applied Mechanics, Professor	Plasma Turbulence Observation System (PLATOS) for puzzling out the principles of structural formation and functional expression in turbulent plasmas	FY2017-2021	448,600
17H06090	Michiharu Wada 50240560	High Energy Accelerator Research Organization, Institute of Particle and Nuclear Studies, Professor	Study of the origin of heavy elements using an innovative mass spectrograph	FY2017-2021	427,100
17H06091	Naoto Chatani 30171953	Osaka University, Graduate School of Engineering, Professor	Development of Next-Generation Transformation Involving Molecular Activation as a Key Step	FY2017-2021	427,300
17H06092	Masahiro Miura 20183626	Osaka University, Graduate School of Engineering, Professor	Revolution of Synthetic Technologies by Deeping C-H Activation Chemistry	FY2017-2021	388,800
17H06094	Yuichi Ikuhara 70192474	The University of Tokyo, School of Engineering, Professor	Atom-by-atom imaging of ion dynamics in nano-structures for materials innovation	FY2017-2021	454,000

Biological Sciences（13 Projects）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26000012	Takashi Kadowaki 30185889	The University of Tokyo and The University of Tokyo Hospital, Project Professor	Comprehensive and expansive research of the universal metabolic regulation mechanisms for health-span	FY2014-2018	394,800
26000013	Takashi Yoshimura 40291413	Nagoya University, Graduate School of Bioagricultural Sciences, Professor	Study of design principle underlying seasonal time measurement and its application	FY2014-2018	294,800
26000014	Keiji Tanaka 10108871	Tokyo Metropolitan Institute of Medical Science, Director General	The Proteasome: Mechanistic Actions and In-depth Physiopathological Analyses	FY2014-2018	312,800
15H05703	Hiroshi Takayanagi 20334229	The University of Tokyo, Graduate School of Medicine, Professor	Promotion of osteoimmunology for understanding the new regulatory systems of vertebrate	FY2015-2019	398,300
15H05704	Shizuo Akira 50192919	Osaka University, Immunology Frontier Research Center, Specially Appointed Professor	Comprehensive analysis of innate immunity	FY2015-2019	433,800
15H05705	Toshiya Endo 70152014	Kyoto Sangyo University, Faculty of Life Sciences, Professor	Elucidation of the integrated cellular network for mitochondrial biogenesis	FY2015-2019	349,300
16H06294	Osamu Nureki 10272460	The University of Tokyo, Graduate School of Science, Professor	Molecular mechanism of membrane proteins regulated by physical stimuli	FY2016-2020	433,300

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
16H06295	Shimon Sakaguchi 30280770	Osaka University, Immunology Frontier Research Center, Specially Appointed Professor	Study of the function and development of regulatory T cells	FY2016-2020	411,500
16H06296	Jian Feng Ma 80260389	Okayama University, Institute of Plant Science and Resources, Professor	Integrated analysis of mineral transport system in crops	FY2016-2020	412,500
17H06095	Masashi Yanagisawa 20202369	University of Tsukuba, International Institute for Integrative Sleep Medicine, Director and Professor	Elucidation of sleep/wakefulness regulation using forward genetic approach	FY2017-2021	423,000
17H06096	Yoshitaka Fukada 80165258	The University of Tokyo, Graduate School of Sciences, Professor	Molecular dissection of robust and flexible circadian clock and its control of animal physiology	FY2017-2021	435,800
17H06097	Ichio Shimada 70196476	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	In situ functional analyses of membrane proteins by NMR	FY2017-2021	354,100
17H06098	Mitinori Saitou 80373306	Kyoto University, Graduate School of Medicine, Professor	Mechanism and Reconstitution In Vitro of Human Germ Cell Development	FY2017-2021	435,300

Grant-in-Aid for Scientific Research on Innovative Areas
(Research in a proposed research area)

☐ Distribution by Research Area of the Newly Adopted Projects

Purpose and Description of Grant-in-Aid for Scientific Research on Innovative Areas (Research in a proposed research area) (excerpt from the "Application Procedures for Grants-in-Aid for Scientific Research"):

1) **Purpose**:
Research aimed at developing a new research area proposed by a researcher or a researcher group that can lead to improvement or strengthening of the scientific level of Japan, through efforts such promotion of joint research and cultivation of research personnel and joint use of facilities.

2) **Total budget provided**:
About 10 to 300 million yen per year

3) **Research period**:
5 years

4) **Number of research projects scheduled to be adopted**:
Around 10 (subject to strict selection)

【 New Projects 】

	Number of Applications			Total Grant Disbursements (FY2018)	Per-project Grants (FY2018)	
	Received	Adopted	Ratio		Average	Largest
			(%)	(Thousands of Yen)	(Thousands of Yen)	(Thousands of Yen)
Humanities and Social Sciences	10	1	10	203,300	203,300	203,300
Science and Engineering	76	7	9.2	1,611,000	230,143	245,200
Biological Sciences	40	3	7.5	732,900	244,300	245,500
Interdisciplinary Area	72	7	9.7	1,557,300	222,471	245,900
Total	198	18	9.1	4,104,500	228,028	245,900

※ Figure reflects only direct funding

【 New and Ongoing Projects 】

	Number of Applications
Humanities and Social Sciences	7
Science and Engineering	37
Biological Sciences	28
Interdisciplinary Area	27
Total	99

List of the Newly Adopted Projects for Grant-in-Aid for Scientific Research on Innovative Areas (Research in a proposed research area) of KAKENHI, FY2018

（1）Humanities and Social Sciences（1 Project）

(Thousands of Yen)

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05443	Shigeo Yamada 30323223	University of Tsukuba, Faculty of Humanities and Social Sciences, Professor	The Essence of Urban Civilization: An Interdisciplinary Study of the Origin and Transformation of Ancient West Asian Cities	FY2018-2022	203,300 / 694,500

（2）Science and Engineering（7 Projects）

(Thousands of Yen)

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05512	Shin-ichi Orimo 40284129	Tohoku University, WPI-AIMR, Professor	HYDROGENOMICS: Creation of Innovative Materials, Devices, and Reaction Processes using Higher-Order Hydrogen Functions	FY2018-2022	222,700 / 1,135,000
18H05436	Shu-ichiro Inutsuka 80270453	Nagoya University, Department of Physics, Professor	A Paradigm Shift by a New Integrated Theory of Star Formation: Expanding Frontier of Habitable Planetary Systems in Our Galaxy	FY2018-2022	240,100 / 1,109,800
18H05535	Tsuyoshi Nakaya 50314175	Kyoto University, Graduate School of Science, Professor	Exploration of Particle Physics and Cosmology with Neutrinos	FY2018-2022	224,900 / 1,129,900
18H05475	Eiji Abe 70354222	The University of Tokyo, Graduate School of Engineering, Professor	Materials Science on mille-feuille structure – Development of next-generation structural materials guided by a new strengthen principle –	FY2018-2022	240,200 / 1,179,000
18H05400	Takashi Nakamura 50272456	Tokyo Institute of Technology, School of Science, Professor	Clustering as a window on the hierarchical structure of quantum systems	FY2018-2022	245,200 / 1,169,700
18H05450	Haruyuki Inui 30213135	Kyoto University, Faculty of Engineering, Professor	High Entropy Alloys: Science of New Class of Materials Based on Elemental Multiplicity and Heterogeneity	FY2018-2022	235,900 / 1,169,100
18H05457	Tadayuki Takahashi 50183851	The University of Tokyo, Kavli Institute for the Physics and Mathematics of the Universe, Professor	Toward new frontiers: Encounter and synergy of state-of-the-art astronomical detectors and exotic quantum beams	FY2018-2022	202,000 / 1,093,000

（3）Biological Sciences（3 Projects）

(Thousands of Yen)

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05428	Akiko Hayashi-Takagi 60415271	Gunma University, IMCR, Full Professor	Constructive understanding of multi-scale dynamism of neuropsychiatric disorders	FY2018-2022	241,900 1,212,900
18H05544	Katsuhiko Hayashi 20287486	Kyushu University, Graduate School of Medical Sciences, Professor	Ensuring integrity in gametogenesis	FY2018-2022	245,500 1,181,700
18H05526	Hiroshi Kimura 30241392	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Chromatin potential for gene regulation	FY2018-2022	245,500 1,181,500

（4）Interdisciplinary Area（7 Projects）

(Thousands of Yen)

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05497	Yasushi Saeki 80462779	Tokyo Metropolitan Institute of Medical Science, Department of Advanced Science for Biomolecules, Associate Director	New frontier for ubiquitin biology driven by chemo-technologies	FY2018-2022	241,900 1,170,100
18H05520	Shigeru Kitazawa 00251231	Osaka University, Graduate School of Frontier Biosciences, Professor	Chronogenesis: how the mind generates time	FY2018-2022	242,900 1,157,200
18H05465	Koichi Suzumori 00333451	Tokyo Institute of Technology, School of Engineering, Professor	Science of Soft Robot: interdisciplinary integration of mechatronics, material science, and bio-computing	FY2018-2022	245,300 1,194,200
18H05505	Naruya Saitou 30192587	National Institute of Genetics, Division of Population Genetics, Professor	Deciphering Origin and Establishment of Japonesians mainly based on genome sequences date	FY2018-2022	91,000 658,800
18H05484	Taku Demura 40272009	Nara Institute of Science and Technology, Graduate School of Science and Technology, Professor	Elucidation of the strategies of mechanical optimization in plants toward the establishment of the bases for sustainable structure system	FY2018-2022	245,200 1,180,500
18H05418	Kazushi Kinbara 30282578	Tokyo Institute of Technology, School of Life Science and Technology, Professor	Molecular Engine: Design of Autonomous Functions through Energy Conversion	FY2018-2022	245,100 1,193,600
18H05408	Takeharu Nagai 20311350	Osaka University, The Institute of Scientific and Industrial Research, Professor	Singularity biology	FY2018-2022	245,900 1,210,100

Title of Project : The Essence of Urban Civilization : An Interdisciplinary Study of the Origin and Transformation of Ancient West Asian Cities

Shigeo Yamada
(University of Tsukuba, Faculty of Humanities and Social Sciences, Professor)

Research Project Number : 18H05443 Researcher Number : 30323223

【Purpose of the Research Project】

Urbanized society appeared for the first time in human history in ancient West Asia and formed a social structure in which the characteristics of each region were determined centered on a city. The remains of the cities of West Asia provide voluminous data about the birth of urban culture and its transformation during ancient times, in the form of abundant archeological records and numerous cuneiform texts written on clay tablets. This project aims to study the process of the appearance of ancient cities, the development of their diverse landscapes and social structures, and interactive relationships between urban societies and the natural environment, to clarify the essential aspects of ancient West Asian cities through interdisciplinary study linking archeology, philology, and the natural sciences. Furthermore, considering the question "What is a city?" by examining regions adjoining West Asia and West Asian cities in later ages, this project will clarify the uniqueness of ancient West Asian cities and their influence on later ages and present a theory of civilization that will be of use in achieving a sustainable future for modern urban civilization.

【Content of the Research Project】

To study the diverse aspects of cities in West Asia diachronically and synchronically based on an interdisciplinary method, four research categories were established: A01 *First Signs of Urban Civilization*; A02 *Landscape and Structure of Ancient West Asian Cities*; B01 *Environment and Resources of West Asia*; and C01 *West Asian Cities from Medieval to Modern Times.* Category A01 clarifies the ways that various elements included in the urban civilization of West Asia emerge before the birth of cities in southern Mesopotamia at the end of the fourth millennium BC. A02 studies diverse aspects of urbanization in Mesopotamia and Egypt during the following 3,000 years by jointly applying the methods of archeology and philology. B01 conducts an analysis of the earth sciences and material chemistry regarding the environment and resources that nurtured and transformed the West Asian urban civilization. C01 clarifies how ancient urban civilization sustained and transformed the traditions of the cities of West Asia from medieval times to the present day and tackles social challenges facing modern West Asian cities. Supplementing such diverse aspects by soliciting invited research, the essence of West Asian cities is diachronically clarified from multiple perspectives. Finally, the characteristics of ancient West Asian urban civilization and its impact on modern times are evaluated historically, sociologically, and culturally.

【Expected Research Achievements and Scientific Significance】

Based on the results of the latest research concerning the historical development of urban civilization in ancient West Asia, an outline encompassing the diverse forms of cities in each region of ancient West Asia is presented in a comparative lattice of space and time. West Asian cities are compared with modern cities, diachronically clarifying the form of West Asian cities from ancient times until the present day. This study also aims to achieve a comprehensive understanding of the *essence of a city* to present a theory of civilization that will be of use in achieving a sustainable future for modern urban civilization.

【Keywords】

Ancient West Asian Urban Civilization: The world's oldest urban civilization, which emerged and developed in the ancient Near East (West Asia).

【Term of Project】 FY2018-2022

【Budget Allocation】 694,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://rcwasia.hass.tsukuba.ac.jp/city/

Title of Project : HYDROGENOMICS: Creation of Innovative Materials, Devices, and Reaction Processes using Higher-Order Hydrogen Functions

Shin-ichi Orimo
(Tohoku University, WPI-AIMR, Professor)

Research Project Number : 18H05512 Researcher Number : 40284129

【Purpose of the Research Project】

Hydrogen in materials exhibits a wide range of concentration, high mobility, quantum nature, and superior chemical reactivity. All these features of hydrogen originate from its bonding and size flexibilities. (Fig. 1)

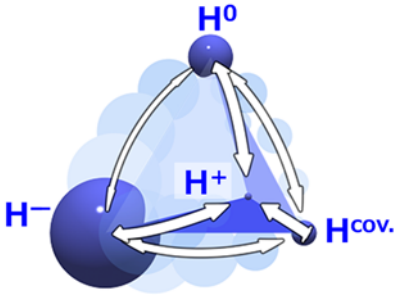


Fig. 1 Hydrogen diagram illustrating the bonding and size flexibility of hydrogen in materials; the spheres located at each vertex represent proton (H^+), hydride ion (H^-), covalently bonded hydrogen ($H^{cov.}$) and neutral hydrogen (H^0). The sizes of hydrogen are also drastically changed according to the bonding states.

The purpose of this project is to develop a new materials science of hydrogen / hydrides (hereafter referred to as “Hydrogenomics”, i.e., hydrogen-omics) as a guideline to "fully utilize" the diverse functionalities of hydrogen in materials.

【Content of the Research Project】

The project will focus on the four most important functionalities of hydrogen originated from its bonding and size flexibilities (hereafter, referred to as “hydrogen functions”); i.e., “high densification ability (A01)”, “interfacial localizability (A02)”, “fast migration ability (A03)” and “high activation ability (A04)”. Then the project will merge them to induce unprecedented “higher-order hydrogen functions (synergistic effect between its individual hydrogen functions)” with the support of “advanced analysis and simulation techniques (A05)”, which will also be developed within this project to capture the hydrogen functions more accurately than ever done before. (Fig. 2)

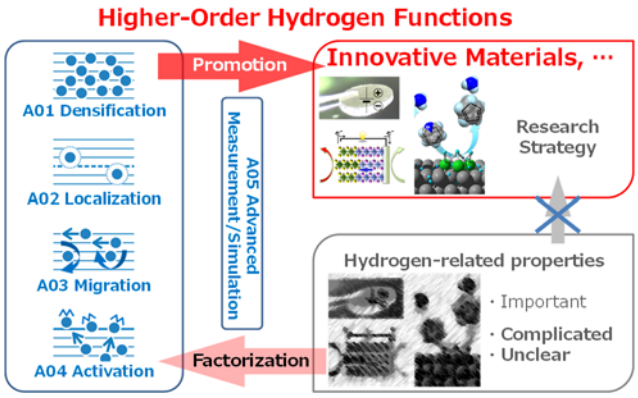


Fig. 2 Strategy of Hydrogenomics.

【Expected Research Achievements and Scientific Significance】

○ Synthesis of hydride superconductors and super-ionic conductors.
○Proof-of-principle for hydride electronics, and enhancement of photovoltaics and high-strength steel properties.
○ Production of advanced energy generation / storage and new-concept devices using hydrogen-electron coupling and hydride super-ionic conductors.
○Performing new material-conversion processes using hydrogen.
○Clarification of the mechanism determining the hydrogen functions and realization of high-accuracy analysis based on hydrogen data-assimilation technique.
○Promotion of young researchers training and social implementation, and formation of international network, in the related research field.

【Key Words】

Hydrogenomics, Higher-order hydrogen functions

【Term of Project】 FY2018-2022

【Budget Allocation】 1,135,000 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.hydrogenomics.jp
orimo@imr.tohoku.ac.jp

Title of Project : A Paradigm Shift by a New Integrated Theory of Star Formation: Expanding Frontier of Habitable Planetary Systems in Our Galaxy

Shu-ichiro Inutsuka
(Nagoya University, Department of Physics, Professor)

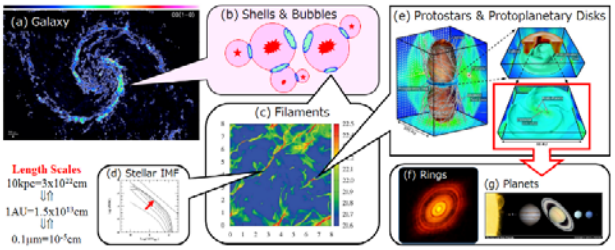
Research Project Number : 18H05436 Researcher Number : 80270453

【Purpose of the Research Project】

Stars are continuously created in our Milky Way Galaxy. Heavy atomic elements, such as metals, are created inside stars and blown out into the interstellar space of the Galaxy. This process provides atomic elements heavier than hydrogen and helium, such as carbon and oxygen, which is critically important for the existence of living creatures in the universe. In our Milky Way Galaxy, the enrichment of heavy elements starts in the inner Galactic regions and gradually expands toward the outer regions of the Galactic disk. This implies that the environment for creating habitable planets and biological entities are developed inside-out in the Galactic Disk over a timescale of the age of the universe. Understanding the origin and evolution of our solar system requires the comprehension of the environment of the birth place of the solar system about 4.6 billion years ago that is expected to be different from its current location in the Galaxy. This requires our understanding of the evolution of our Galaxy itself, over the timescale comparable to the age of the universe. We will try to understand this by extending the recently developed theory of star formation and describing the formation of star clusters. In addition, we will develop the planet formation theory and try to solve multiple puzzling questions regarding the origin of the solar system. This would be done by the collaboration of all the relevant researchers in Japan and this work is expected to lead a paradigm shift in the investigation of the origin of our solar system. We will also try to find possible siblings of the Sun that would have been born at the same time in the same star cluster, i.e., the expected birth place of the Sun. The results of our project are expected to provide a quantitative picture for the distribution of habitable planets in the Galaxy, and hence, provide a new strategy for future observations of exo-planets.

【Content of the Research Project】

[A01] Theory for the Formation of Star Clusters and the Evolution of Our Galaxy
[A02] Theory for the Formation of Planetary Systems from Diverse Protoplanetary Disks
[A03] Theoretical and Observational Studies of the Formation and Evolution of Diverse Planetary Atmospheres
[B01] Observational Studies on the Formation of Star Clusters in Giant Molecular Clouds
[B02] Observational Studies on the Evolution of Protoplanetary Disks in Diverse Environments
[B03] Innovation of Infrared Observations of Young Planets and Habitable Planets



【Expected Research Achievements and Scientific Significance】

We will describe the time evolution of the formation rate and the mass function of star clusters and establish a quantitative picture of the Galactic chemical evolution. We will also investigate theoretically and observationally the existence of different types of exo-planets and understand the diversity of planet formation in our evolving Galaxy. These studies are expected to provide a deep understanding on the origin of our solar system.

【Key Words】

Galactic Chemical Evolution: The enrichment of heavy elements in the Galaxy.
Molecular Clouds: Low temperature (~10K) clouds in the interstellar space that are mostly composed of molecular hydrogen: The birthplace of stars.
Protoplanetary Disks: Rotating gaseous disks created around new-born stars: The birthplace of planets.
Exo-Planets: Planetary systems found outside of our solar system.
Habitable Planets: A certain type of planets that may possess liquid water on their surface, and hence, may potentially provide a chance to host biological entities.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,109,800 Thousand Yen

【Homepage Address and Other Contact Information】
http://www.ta.phys.nagoya-u.ac.jp/star/

Title of Project : Exploration of Particle Physics and Cosmology with Neutrinos

Tsuyoshi Nakaya
(Kyoto University, Graduate School of Science, Professor)

Research Project Number : 18H05535 Researcher Number : 50314175

【Purpose of the Research Project】

Today, Particle Physics and Cosmology are in a big turning point. The standard model of Particle Physics is well verified in a wide energy range up to TeV with the development of accelerators. Standard Cosmology describes Nucleosynthesis in the evolution of our universe, and firmly establish the existence of dark matter and dark energy. However, Standard Model and Standard Cosmology can not explain the origins of asymmetry between matter and anti-matter in our universe, the origin of inflation, the unified picture between forces and particles consisting of matter. To understand a picture from the beginning of our universe to the present, we must innovate a novel concept of Particle Physics and Cosmology. We challenge to build the new concept of Particle Physics and Cosmology by studying "neutrinos" that are the essential key particle to address these unresolved problems.

【Content of the Research Project】

We proceed with the world's best neutrino experiments: Super-Kamiokande, T2K, and IceCube, and we study neutrino oscillations, explore CP violation, and advance neutrino astronomy. Furthermore, in order to investigate the Grand Unification Theory and the initial state of our universe, we search for proton decay, measure neutrino mass from observation of Cosmic Microwave Background (CMB), and search for the signal of inflation (primitive gravity wave). In addition, we also study the Majorana nature of neutrinos.

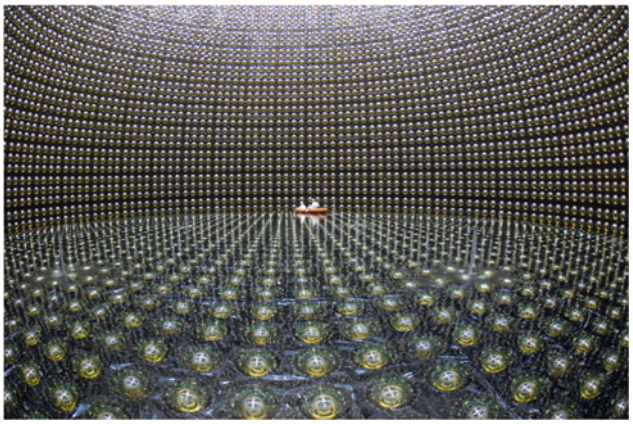


Fig-1 : Super-Kamiokande Detector

In order to realize the next-generation neutrino experiments, we proceed with the development of basic technologies of Hyper-Kamiokande and IceCube Gen 2 experiments. With neutrinos, our research integrates particle physics, nuclear physics, cosmic rays, and cosmology.

【Expected Research Achievements and Scientific Significance】

[Development of neutrino physics]: Determination of neutrino oscillations with high precision. Adding absolute neutrino mass and the number of generations, we advance understanding of the origin of neutrino mass and mixing.

[Evolution of neutrino astronomy]: We study Cosmic Neutrino Background, and observe neutrinos from sun, supernovae, galactic extraterrestrial objects, and AGN.

[Great Unified Theory (GUT)]: We search for the proton decay as an evidence of unification. By examining the symmetry between quarks and leptons, the GUT models are constrained.

[Elucidation of the evolution of our universe]: We have a big discovery potential to primitive gravitational waves, the origin of asymmetry between a particle and an anti-particle, dark matters, the B mode polarization of CMB.

【Key Words】

Neutrino: Neutrinos are elementary particles, similar to electrons but with no electric charge. There are three types of neutrinos. Non-zero neutrino mass was discovered by Super-Kamiokande. Neutrinos change their types through a phenomenon called “neutrino oscillation”. Study of neutrino oscillations has advanced understanding nature of neutrinos.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,129,900 Thousand Yen

【Homepage Address and Other Contact Information】

http://www-he.scphys.kyoto-u.ac.jp/nucosmos/
majourt.nakaya@scphys.kyoto-u.ac.jp

Title of Project : Materials Science on mille-feuille structure - Development of next-generation structural materials guided by a new strengthen principle -

Eiji Abe
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05475 Researcher Number : 70354222

【Purpose of the Research Project】

In order to solve the energy problem and realize a sustainable society, one of the prominent issues in materials science is to develop high-strength, light-weight structural materials. In our research project, we establish the "Kink strengthening phenomenon" as a universal strengthen principle, which has been firstly discovered in the LPSO-structured Mg alloy that revealed unusual high-strength beyond theoretical predictions. The LPSO structure can be generally viewed as "Mille-feuille structure", in the sense that they are constructed by alternate stacking of microscopic hard- and soft-layer. Establishing a universal kink principle applicable to any mille-feuille structures will lead to a new academic, innovative area. Furthermore, based on the established "kink strengthening principle", we will be able to design new alloys including Ti and Al alloys and further new polymer materials, providing an exciting opportunity for the development of next generation structural materials.

【Content of the Research Project】

Since kink formation and strengthening are not fully understood yet along with the existing solid deformation theory, it is indispensable to provide cross-disciplinary opportunities beyond the conventional frameworks, in order to establish a new academic field "Materials Science of a Mille-feuille structure". In our research project, researchers participate across the wide research fields that are indispensable for the present tasks, the major three of which are "Materials synthesis (monozukuri)" "Solving the kink mechanism (elucidation of fundamental properties)" "Theory construction (universal principle/concept)". We will be all together to form "Japan National Team" to tackle these challenging issues, creating a new universal academic field.

There are four research groups in our project. In **A01 group**, along the experiences with the LPSO-type Mg alloys, we will attempt to develop novel Mg alloys having various mill-feuille structures. In **A02 group**, we will try to elucidate the kink mechanism by performing mechanical experiments, advances structural measurements and computation modeling. In **A03 group**, a kink strengthening theory will be constructed under the effective collaborations between multiple fields including materials science, mechanics, physics and mathematics. In **A04 group**, we will try to develop and synthesize novel metal- and polymer-base Mille-feuille materials according to a proposed kink strengthening theory.

【Expected Research Achievements and Scientific Significance】

❶ Establishing a novel strengthening principle of the Millefeil structure makes it possible to develop higher strength structural materials including new Mg, Ti and Al alloys, and further polymer based materials, contributing to an establishment of a energy-saving, sustainable society.

❷ Establishment of the systematic kink strengthening theory of the Millefeil structure is engraved in history as a new material strengthening method, and hence leads to worldwide reputation in a material science field.

❸ Elucidation of the kink strengthening mechanism, based on the hierarchical structure science from the atomic level to the mesoscopic structures, brings out a drastic extension into a new solid mechanics that includes novel geometry and non-linear elastic theory.

❹ Establishment of a new academic field "Materials Science of a Mille-feuille Structure" brings a great influence on wide basic-research fields, as well as an effective growth of the engineering fields and the relevant industry.

【Key Words】

Mille-feuille Structure: A microscopic layered structure constructed by an alternate stack of hard-layer (strongly-bonded) and soft-layer (weakly-bonded). It is named after "Mille-feuille cake", which is composed of a pie layer (hard layer) and a cream layer (soft layer).

【Term of Project】 FY2018-2022

【Budget Allocation】 1,179,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.mfs-materials.jp
abe@material.t.u-tokyo.ac.jp

Title of Project : Clustering as a window on the hierarchical structure of quantum systems

Takashi Nakamura
(Tokyo Institute of Technology, School of Science, Professor)

Research Project Number : 18H05400 Researcher Number : 50272456

【Purpose of the Research Project】

We aim to understand the formation mechanism of the hierarchical structure of quantum particles, from quarks to molecules (Fig.1). For this purpose, we integrate our research activities on hadron, nuclear, atomic physics, and molecular science, where Japan has played leading roles, and establish a research consortium to fill the large gaps among the conventional research fields. A variety of novel clustering phenomena will be primary targets of the research, which will clarify not only universal phenomena and physical laws, but also characteristic features of each hierarchy. We thus open a new research field to investigate the origin of hierarchies of matter.

【Content of the Research Project】

The quantum world has a hierarchical structure, from quarks to molecules (Fig.1). Each hierarchy is characterized by its unit particles and interactions between them. The unit particle, composed of lighter particles, is called a cluster. Recently, as shown in Fig.1, "Semi-hierarchy" lying between the conventional hierarchies, and its constituents, novel clusters, have drawn much attention. Such clusters may have universality across different hierarchies, and thus can provide a key to understand the hierarchical structure. As shown in Fig.2, Groups A,B,C will investigate clusters and interactions between them in each hierarchy. Group C, in addition, will explore quantum simulators to understand the clustering phenomena more generally. Group D will develop relevant theories. With this combined expertise, we expect to understand the underlying mechanism of the hierarchical structure.

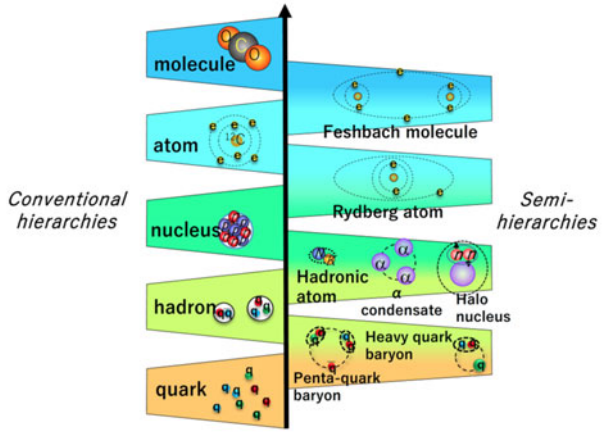


Fig.1 Hierarchical structure of matter

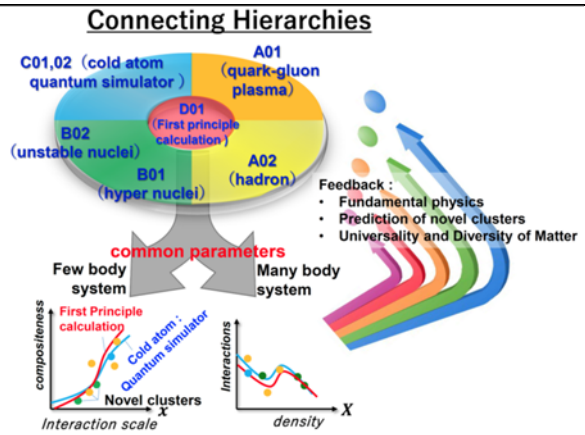


Fig.2 Scheme of this project

【Expected Research Achievements and Scientific Significance】

Novel clusters in semi-hierarchies will be observed and established. In addition, the interactions between the novel clusters will be investigated. Theories will play important roles in understanding the interactions from first principles. Quantum simulators using ultra-cold atom experiments will be one of the significant achievements. A semi-hierarchy with mixed configurations can be analyzed by quantum simulators, which will allow us to understand the phenomena in a more unified way. We thus expect to find physics phenomena and laws universally applicable to multiple hierarchies. In this way, we will open a new research field connecting the multiple hierarchies, from quarks to molecules, through the study of clustering phenomena.

【Key Words】

Cluster: A unit particle of the respective hierarchy, composed of lighter particles.
Semi-hierarchy: A hierarchy between two conventional hierarchies, often characterized by weakly (un)bound systems, strong pairing, mixed configurations, showing some universal features.
Quantum simulator: Simulators of quantum clusters to be realized by ultra-cold atom experiments.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,169,700 Thousand Yen

【Homepage Address and Other Contact Information】
http://be.nucl.ap.titech.ac.jp/cluster/

Title of Project : High Entropy Alloys: Science of New Class of Materials Based on Elemental Multiplicity and Heterogeneity

Haruyuki Inui
(Kyoto University, Faculty of Engineering, Professor)

Research Project Number : 18H05450 Researcher Number : 30213135

【Purpose of the Research Project】

This project aims at establishing a new science concerning high-entropy alloys that exhibit new and peculiar materials properties by elucidating nonlinear interactions among various constituent elements through intensive and interdisciplinary cooperative research among research groups of various research fields within the project. 'High-entropy alloys' is defined in a narrow sense as equiatomic solid-solution alloys formed with constituent elements more than five kinds, the subjects of research have recently been expanded to include concentrated alloys with chemical compositions in the middle of multi-component phase diagrams, even they are deviated from the equiatomic compositions and contain precipitates of the secondary phase. Many of these high-entropy alloys of broader sense exhibit peculiar mechanical properties, such as abnormally high strength and high toughness at low temperatures, high strength retention at high temperatures, which are not observed in conventional alloys. These peculiar materials properties are considered to arise from the so-called 'cocktail' effects (nonlinear interactions among various constituent elements), and the identification of materials property expression behind the cocktail effects is one of the most challenging topics in materials science. Through establishing new scientific principle for controlling variety and inhomogeneity of elements, we aims at creating a new scientific area, in which the basis is established for developing new peculiar materials beyond conventional ones.

【Content of the Research Project】

In this research area, the following three research items are promoted cooperatively to establish a new scientific area with the concept of High-Entropy Alloys.

- Research Item A01: Identification of Materials Property Expression and Materials Development
- Research Item A02: Modelling and Designing of Materials Property
- Research Item A03: Controlling of Phase Stability and Microstructures

For all three items, several experimental and theoretical research groups will collaborate closely together to promote the understanding of cocktail effects of high-entropy alloys.

【Expected Research Achievements and Scientific Significance】

Unlike conventional alloys (such as Ni- and Al-based alloys) that are developed with a particular principal element at a corner of the phase diagram, high-entropy alloys are to be developed in the middle of multi-component phase diagrams, which have been undiscovered. Many unknown alloys with excellent properties are therefore expected to be discovered. Some particular combinations of elements may generate a cocktail effect that is not predictable only from the combination, and we expect a paradigm shift to occur in materials development, so that a best combination of elements and their fractions is searched, departing from conventional ways with one particular principal element and some minor alloying elements.

【Key Words】

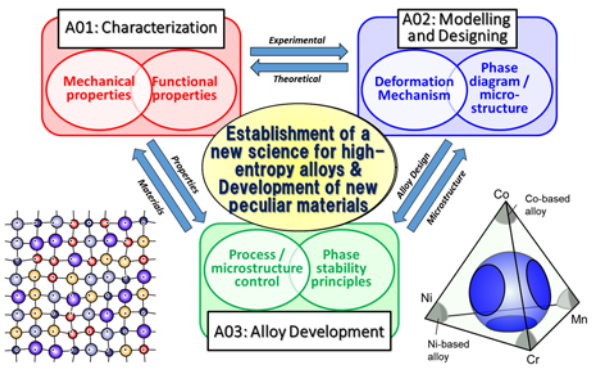
High-entropy alloy, Multi-component equiatomic alloy, high-order solid-solution, cocktail effect, materials strength, fracture toughness, solid-solution strengthening, phase stability, trap effect, variety of elements, inhomogeneity of elements

【Term of Project】 FY2018-2022

【Budget Allocation】 1,169,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.highentropy.mtl.kyoto-u.ac.jp



Title of Project : Toward new frontiers: Encounter and synergy of state-of-the-art astronomical detectors and exotic quantum beams

Tadayuki Takahashi
(The University of Tokyo, Kavli Institute for the Physics and Mathematics of the Universe, Professor)

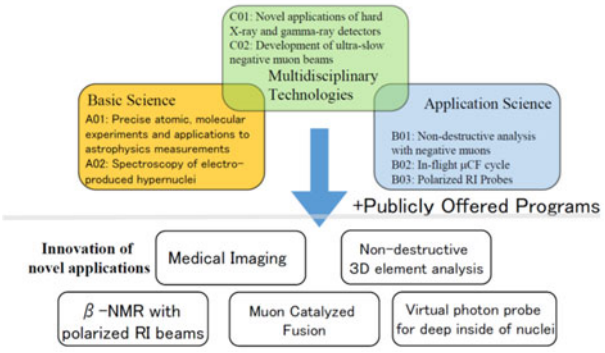
Research Project Number : 18H05457 Researcher Number : 50183851

【Purpose of the Research Project】

In recent years, a variety of fundamental scientific research fields have been established due to the production of various high-intensity quantum beams created by accelerators. However, these studies have been carried out independently and not enough effort has been made to share theoretical progresses and technological advances to other research fields. Based on the World-renowned advanced detector technology developed in Japan for space X-ray and gamma-ray observations, we will establish common theoretical frameworks and technological platforms and combine them with exotic quantum beams, namely negative muons, virtual photons and polarized RI beams. This will enable us to perform cooperative works in different research fields and develop novel methods. Furthermore, this will not only contribute to the area of fundamental sciences, but also towards new applications such as non-destructive 3D element analysis and medical applications.

【Content of the Research Project】

We aim to advance X-ray and γ-ray imaging technologies and apply them to different research fields of quantum-beam experiments and to various other applications such as non-destructive analysis and medical imaging.
(1)Precise spectroscopic measurements will be performed by detecting muonic X-rays combined with ultra-high resolution X-ray spectrometer and cadmium telluride (CdTe) semiconductor sensors. In addition, using the common framework of few-body theory combined with precise electro- magnetic spectroscopy of Λ hypernuclei utilizing real and virtual photons, hypernuclei in wide mass region will be studied to clarify the baryonic force and solve the puzzle of heavy neutron stars.
(2)A nondestructive 3D imaging element analysis method will be established using muonic atom characteristic X-rays for bulk samples, and studies will be conducted on extraterrestrial samples and archeology artifacts. Scientific research on muon catalyzed fusion will also be promoted based on a newly proposed reaction using high-intensity negative muon beam. Furthermore, by creating highly polarized RI beam without element dependence and replacing RI with atomic nucleus in a substance, material science research will be advanced by using the ultra-sensitive beta-radiation detected NMR method similar to μSR.
(3)Advanced detector system required for expanding the field as well as ultra-slow negative muon beam development will be carried out. Collaborative research with scientists in medicine and pharmacy will be initiated to develop in vivo 3D γ-ray imaging device for small animals by applying CdTe semiconductor sensors to medical research on cancer stem cells.



Organization of the Project

【Expected Research Achievements and Scientific Significance】

Unprecedented precision experiments with newly developed detectors and exotic quantum beams will be realized in this program. A common theoretical framework of few-body systems will be established based on these experimental results. Especially, a research on exotic atoms using negative muons as "probes" has dramatically progressed, and application of muonic characteristic X-rays as ultra-sensitive non-destructive element analysis can finally be realized.

Highly-sensitive in vivo γ-ray 3D imaging device with CdTe semi-conductor sensor technology will initiate studies of the properties and diversity of cancer cells in a tumor. Gathering researchers from various fields of expertise and generating ideas through brainstorming creates a "platform that facilitates the creation of new concepts".

【Key Words】

Negative muon: An elementary particle with similar properties as an electron but is 200 times heavier in mass.

Cadmium telluride (CdTe): For 100-keV γ-rays, it has 100 times higher detection efficiency than Si.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,093,000 Thousand Yen

【Homepage Address and Other Contact Information】

https://member.ipmu.jp/SpaceTech_to_QuantumBeam

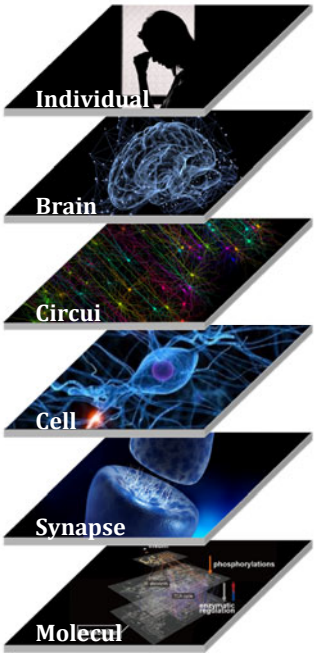
Title of Project : Constructive understanding of multi-scale dynamism of neuropsychiatric disorders

Akiko Hayashi-Takagi
(Gunma University, IMCR, Full Professor)

Research Project Number : 18H05428 Researcher Number : 60415271

【Purpose of the Research Project】

Despite extensive recent efforts, the pathogenesis of psychiatric disorders remains poorly understood, mainly because their pathophysiology is a synergistic interaction between multiple genes variants and environmental factors. Thus, what we recently know as contributory factors for the diseases is the susceptible gene variants (Molecular layer), synaptopathy (Subcellular and Cell layer), alteration in neuronal circuits (Circuit layer), conceivably resulting in the behavioral manifestations (Individual layer). However, the understanding of each layer has been limited within a single layer, which hinders the integrative and causal mechanistic understanding of behaviors. Probably, each layer can affect one another, macroscale to the mesoscale and then to the microscale layer or vice versa. Thus, we deal with phenomena of intricate complexity of psychiatric disorders that are governed by various mechanisms integrated across multiscale layers.



【Content of the Research Project】

In this study, we aim at a constructive understanding of multiscale hierarchical nature of psychiatric disorders with use of recently available state-of-art techniques: hypothesis-free and comprehensive omics technologies and powerful simulation/analysis tools generate new types of heterogeneous data with a density and depth previously unimaginable, which can handle big data from multiscale layers ranging from molecules/ synapses/neurons/circuit (and ideally, all the way to behavior).

For instance, the role of genes identified by genetic analysis of families of psychiatric disorders as well as molecules identified by omics analysis of postmortem brain samples will be analyzed and subject to the construction of mathematical models. Using animal models of the candidate genes, a responsible neural circuit will be identified by behavioral and anatomical analyses. Within that neural circuit, responsible cell types will be identified using omics analysis and the mechanism for the emergence of behavioral changes will be pursued by manipulation of a specific neural circuit and by employing mathematical modeling of the responsible neural circuit. By using induced pluripotent stem (iPS) cells derived from patients with psychiatric disorders, neural cells and cerebral organoids will be generated and cellular pathology underlying mental disorders will be studied using omics analyses.

【Expected Research Achievements and Scientific Significance】

Through the series of studies as described above, a mathematical model of psychiatric disorders that incorporate multiple layer facets including molecular, cellular, circuit and behavioral levels, will be constructed and thereby we will aim at a constructive understanding of the multiscale phenomena of psychiatric disorders. One of the goals of neuroscience research is to elucidate how specific neuronal populations form functional neuronal circuits are altered in the disease state. Findings based on our strategy that would causally identify the contributory factors for the disease will provide the knowledge necessary to establish circuit-centric therapeutics as well as the rationale molecular (and chemistry) based drug designs.

【Key Words】 Psychiatric disorders, Multiscale, Constructive understanding, Optical manipulation, Modeling, Transomics

【Term of Project】 FY2018-2022

【Budget Allocation】 1,212,900 Thousand Yen

【Homepage Address and Other Contact Information】
http://multiscale-brain.umin.ne.jp
hayashitakagi888@gmail.com

Title of Project : Ensuring integrity in gametogenesis

Katsuhiko Hayashi
(Kyushu University, Graduate School of Medical Sciences, Professor)

Research Project Number : 18H05544 Researcher Number : 20287486

【Purpose of the Research Project】

Gametes are highly specialized cells for the creation of new individuals. To finally become functional gametes, the germ cell lineage including the precursors undergoes a unique series of differentiation processes. Quality of germ cell lineage closely relate to viability of embryos and individuals. The aim of this project is to understand how the functionality of gametes, named "gamete integrity", is established during gametogenesis *in vivo*. Based on this knowledge, the project also aims to reconstitute the process *in vitro*.

Recently, the research members in this project succeeded in production of functional gametes *in vitro* (*in vitro* gametogenesis) by culturing reproductive organs or inducing differentiation of pluripotent stem cells. However, the developmental potential of the gametes from *in vitro* gametogenesis was extremely limited, suggesting that gamete integrity was not properly reconstituted in culture. Therefore, this project will try to understand the molecular mechanisms and biological processes for construction of gamete integrity *in vivo*. The project includes the technological development of a non-invasive system to evaluate gametes. Based on this knowledge, we try to establish *in vitro* gametogenesis that can firmly and stably reconstitute gamete integrity.

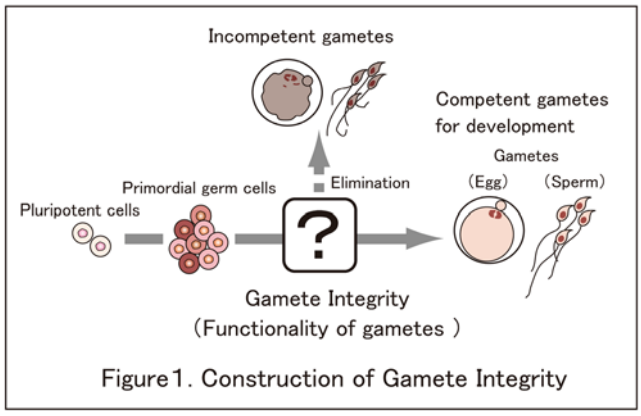


Figure 1. Construction of Gamete Integrity

【Content of the Research Project】

This project is composed of three subjects (A01-A03) to achieve the aim. In A01, we focus on the development of the culture system to reconstitute gamete integrity. In A02, we plan to identify the molecules regulating gamete integrity, which includes development of the non-invasive system. In A03, we want to understand the biological process needed for selection of competent gametes (and eliminate incompetent gametes).

A01 will optimize culture conditions, develop novel culture devices, purify proteins and substances required for gametogenesis, and produce supporting somatic cells from pluripotent stem cells. A02 will identify genes regulating gamete integrity by comparison between competent and incompetent gametes, which are sorted by the non-invasive system. A03 will identify the heterogeneity of the germ cell population, analyze gene expression at the single cell level, and understand the biological significance of the heterogeneity.

By combining all the knowledge, we will gain deep insights into gamete integrity and reconstitute it *in vitro*.

【Expected Research Achievements and Scientific Significance】

We expect to identify molecules (genes, proteins and other substances) that have critical roles on gametogenesis. Understanding of the biological process for gamete selection will provide important information for the field of biology, in particular reproductive biology, developmental biology and evolutionary biology. The establishment of *in vitro* gametogenesis that efficiently produces competent gametes will have many experimental applications. Finally, this project will provide scientific evidence to apply to human *in vitro* gametogenesis.

【Key Words】

Gamete integrity, Developmental potential, *in vitro* gametogenesis, non-invasive system, heterogeneity

【Term of Project】 FY2018-2022

【Budget Allocation】 1,181,700 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.gamete-integrity.com

Title of Project：Chromatin potential for gene regulation

Hiroshi Kimura
(Tokyo Institute of Technology, Institute of Innovative Research, Professor)

Research Project Number：18H05526　Researcher Number：30241392

【Purpose of the Research Project】

In multicellular organisms, diverse cell phenotypes arise from identical genetic information in DNA. The diversity in phenotypes is achieved by differential gene expression in different cell types. Therefore, understanding the mechanism of gene regulation is one of the most important subjects in biology.

Genetic information in eukaryotes is packed into the nucleus through the formation of chromatin. Recent studies have revealed that chromatin structure plays an important role in gene regulation. However, the big question of "how chromatin regulates gene expression in living cells" remains unclear. Recent imaging techniques to track particular chromatin structures in living cells have allowed us to link chromatin structure with transcription potency. In this research program, we aim to reveal the factors that determine the "chromatin potential" for gene activation (Fig. 1).

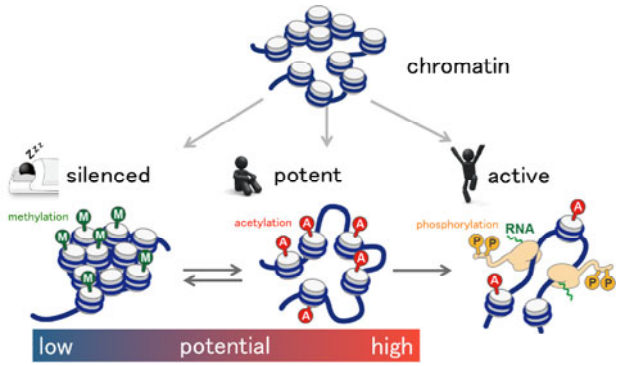


Fig. 1: The concept of "chromatin potential".

【Content of the Research Project】

Genes are regulated at various levels of chromatin, including post-translational histone modifications, histone variant exchange, chromatin condensation, higher-order nuclear compartmentalization, interactions with nuclear domains, and physical forces (Fig. 2). By gathering top researchers with different expertise, this research group will help reveal the nature of chromatin potential through interdisciplinary approaches, including quantitative measurements of chromatin dynamics, acquisition of omics data, reconstitution of functional chromatin *in vitro* and *in vivo*, and theoretical modeling. By integrating the data obtained from different approaches, we will be able to address which factors contribute and to what extent each helps establish transcriptionally competent or incompetent chromatin states. This research group will focus on biological phenomena associated with dynamic changes in chromatin and gene expression, such as development and differentiation in model organisms.

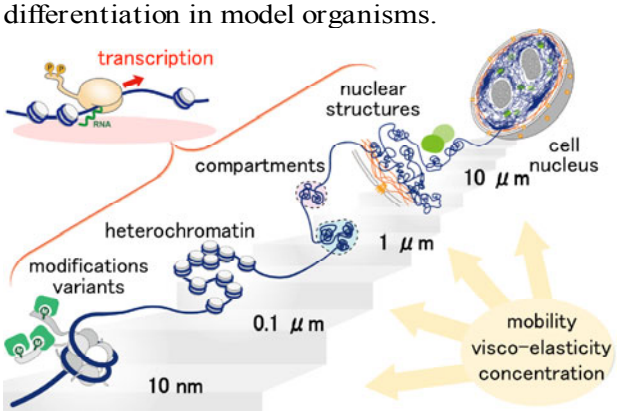


Fig. 2: Various levels that determine chromatin potential.

【Expected Research Achievements and Scientific Significance】

By revealing the factors that control chromatin potential, we expect to predict and control the probability of gene expression through the measurement and manipulation of chromatin states. This study will open up new routes to designing cell properties and fate by artificially controlling gene expression, which in turn will contribute to broad fields of applied biology.

【Key Words】

Chromatin: A complex in the eukaryotic nucleus, consisting of DNA, protein, and RNA. The major components of chromatin are DNA and histone protein.

【Term of Project】

FY2018-2022

【Budget Allocation】

1,181,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.nibb.ac.jp/potentia/
hkimura@bio.titech.ac.jp

Title of Project : New frontier for ubiquitin biology driven by chemo-technologies

Yasushi Saeki
(Tokyo Metropolitan Institute of Medical Science, Department of Advanced Science for Biomolecules, Associate Director)

Research Project Number : 18H05497 Researcher Number : 80462779

【Purpose of the Research Project】

Ubiquitin research today is deeply connected with almost all areas of life science research. The diversity of ubiquitin's functions can be attributed to the structural variety of ubiquitin modification, called the 'ubiquitin code'. However, these ubiquitin codes are more diverse and dynamic than expected, and the decoder molecules are also diverse, making it difficult to see the overall principles of ubiquitin codes. In addition, an increasing number of ubiquitin-associated diseases have been identified, but pathogenetic mechanisms have been elucidated for only a limited number. Hence, the research methods and tools for analyzing each ubiquitin-dependent pathway are in urgent demand.

This research project employs chemo-technologies as a new research tool to decipher, manipulate, and create ubiquitin codes. The objective is to elucidate as-yet-unknown principles of ubiquitin function in detail, as well as to establish novel techniques for ubiquitin-mediated regulation of cellular function.

【Content of the Research Project】

In close collaboration with life scientists and organic chemists, the project will progress on two fronts: understanding the mechanisms of ubiquitin codes using chemo-technologies (A01), and developing chemo-technologies for analyzing ubiquitin codes (A02) (Fig.1). The research group will be equipped with an extensive research support system that includes tools and equipment for compound screening, peptide synthesis, state-of-the-art proteomics analysis, and protein structure analysis. Specifically, to elucidate the mechanisms of ubiquitin code in each ubiquitin-dependent pathway, we will develop small-molecule compounds or stapled peptides that enable immediate inhibition of the particular function of each ubiquitin modification or decoder molecule. Also, by combining chemo-technologies with state-of-the-art proteomics analysis, this project will explore novel ubiquitin codes and decoder molecules, and simultaneously enable direct analysis of the higher-order structure of ubiquitin chains. On the other hand, by manipulating ubiquitin codes with small-molecule compounds, we will explore methodology for not only degradation, but also localization and activation of particular proteins.

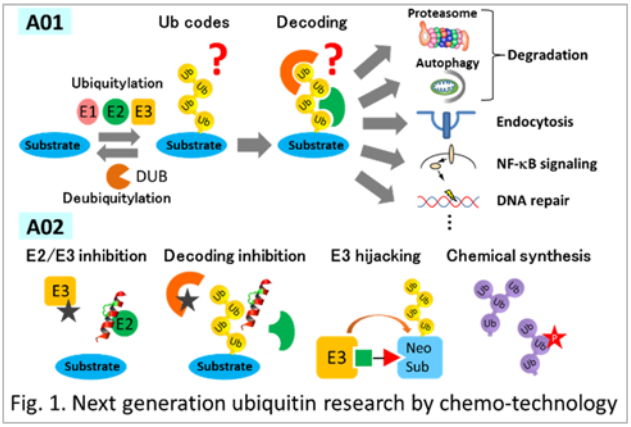


Fig. 1. Next generation ubiquitin research by chemo-technology

【Expected Research Achievements and Scientific Significance】

Our research project will markedly improve our understanding of the mechanisms of ubiquitin codes. The chemical tools developed in this project can be applied to discovery of new biology pathways involving ubiquitin and correct understanding of the pathogenesis of ubiquitin-associated diseases, as well as drug development. Our project will also promote a new collaborative style between biologists and chemists.

【Key Words】

Ubiquitin code: Information about various functions coded in the higher-order structure of various ubiquitin modifications.
Chemo-technology: Chemical techniques including the development and use of small-molecule compounds, stapled helical peptides, and agents that induce targeted protein degradation.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,170,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ubiquitin.jp/

Title of Project : Chronogenesis: how the mind generates time

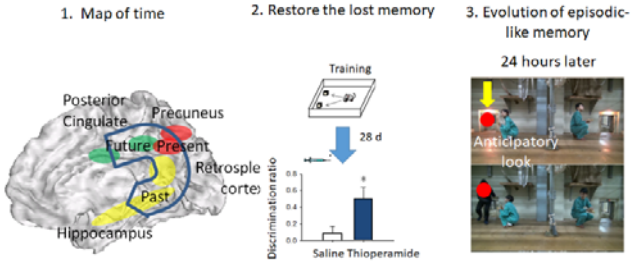
Shigeru Kitazawa
(Osaka University, Graduate School of Frontier Biosciences, Professor)

Research Project Number : 18H05520 Researcher Number : 00251231

【Purpose of the Research Project】

We discriminate the present from the past and the future while we live our daily lives. Where does the awareness of time, which we term "mental time", come from? In our previous five-year project, "The Science of Mental Time", we achieved three major goals as follows.

1) We successfully drew a map of mental time



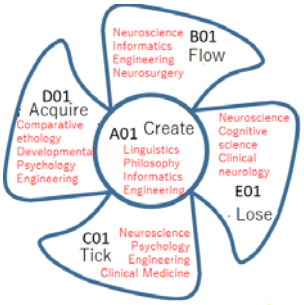
over the medial surface of the cerebral cortex.

2) We developed methods for manipulating mental time in lab animals, and initiated clinical applications
3) We clarified the ontogeny and the phylogeny of the episodic-like memory.

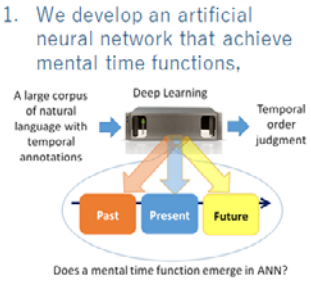
To make a further step forward, we "creates" an artificial neural network that achieves mental time functions, and use it as a control to be compared with the brain. Through the comparison, we address four critical question. 1) How does a sense of continuous "temporal flow" emerge? 2) How are rhythmic brain activities related with our awareness of time? 3) How do we "acquire" time through development and evolution? 4) How do we "lose" our time in neurological and mental diseases?

【Content of the Research Project】

This project consists of five sub-projects. Sub-project A01, located in the center of the five, "creates" an artificial neural network that outputs the order of two events when it receives multiple sentences sampled from a text corpus. The other four sub-projects, characterized by key words such as "Flow" (B01), "Tick" (C01), "Acquire" (D01), and "Lose" (E01), address each of the four above-mentioned questions.



【Expected Research Achievements and Scientific Significance】



Five achievements are expected from our collaborative and interdisciplinary studies.

1) We will develop artificial neural networks that achieve our mental time functions.
2) We will clarify how the map of time functions and emerges.
3) We will provide solid scientific answers to naive questions like "Why do we feel nostalgic for the past?", and "Why does time fly when we have fun?".
4) We will develop new methods for evaluating and manipulating mental time, and initiate clinical applications for screening and ameliorating the symptoms of diseases with mental time dysfunctions like dementia.
5) We will clarify similarities and differences in the mental time functions between the human and the other species, and between adults and children.

【Key Words】

Mental time: an awareness of time as being past, present, and future, specifically evolved in humans. Mental time is constructed by the brain and does not therefore necessarily coincide with time in the physical world.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,157,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.chronogenesis.org/
kitazawa@fbs.osaka-u.ac.jp

Title of Project : Science of Soft Robot: interdisciplinary integration of mechatronics, material science, and bio-computing

Koichi Suzumori
(Tokyo Institute of Technology, School of Engineering, Professor)

Research Project Number : 18H05465 Researcher Number : 00333451

【Purpose of the Research Project】

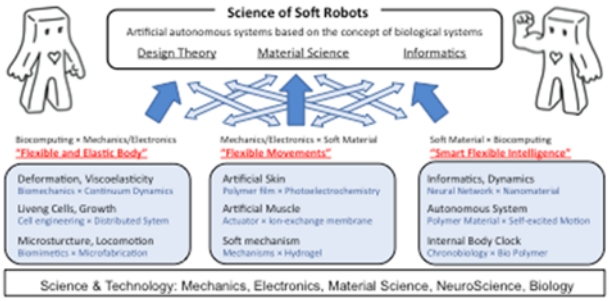
In this area, we focus on "softness" peculiar to organisms as the platform of life phenomena. In various fields, academic studies that refer to softness occur individually. The international trend of science and technology "from hard to soft" is the background toward science and technology that is close to human and living things. A science that organically bundles biology, information science, material science, and mechanical/electronic engineering is an unexplored area, and integration is desired. Introduction of softness brings an essential change accompanying the construction of a new academic area and we believe that a vast knowledge will be opened.

In this project, we propose "artificial autonomous systems based on the concept of biological systems" with the features of living organisms and define them as "soft robots" anew. The soft body of a living thing, its form, structure, mechanism, and information processing are fundamentally different from artificial things we can build at the present day. We call this frontier the new academic area "Science of Soft Robots." The aim of this area is to integrate new academic challenges in each field and to create an active academic trend toward science of soft robots.

【Content of the Research Project】

The new academic area "Science of Soft Robots" not only imitates and reproduces organisms but also learns from living things, but also to learn from biological systems and to make artificial systems beyond living things. The framework consists of "soft robot design theory", "soft robot material science", and "soft robot informatics".

Soft Robot Design Theory aims to blend mechatronics and biomechanics. It aims to allow flexible and elastic body. Also included is a biohybrid device incorporating living cells. Soft Robot Material Science creates flexible movements by smart material that has never been used on machines. We focus on soft mechanisms, electronics with extreme softness/elasticity, artificial muscle comparable to biological muscle using polymer material. Soft Robot Informatics aims to design smart and flexible intelligence in which software and hardware are inseparably combined. By utilizing the soft material dynamics as an information processing device, we aim to break through the limits of conventional information processing. In addition, by introducing a chemical reaction system on a soft body, we obtain spontaneous periodic motion and chemical body clock.



【Expected Research Achievements and Scientific Significance】

Through collaboration among interdisciplinary researchers who have never before met, the following academic outcomes are expected. First of all, it is possible to reveal principles of skillful soft mechanisms found in the animals and realization by artificial systems. From the viewpoint of material science, we can provide new actuators, flexible sensors, and soft energy source utilizing a functional polymer material and an electrochemical phenomenon. As a contribution to robotics, it is possible to provide a theoretical framework of continuum dynamics that handles nonlinearity and large deformation of soft materials. It is also expected to have soft mechanics using a functional hydrogel. For information processing technology, we will show that soft behavior of complex body can be used as a computational resource different from semiconductor chip.

As a social return of academic outcomes, various applications utilizing safety due to softness, biocompatibility are conceivable. Soft robots that can coexist with humans are expected to develop into safe and intellectual physical exercise support in an aging society, realization of safe mobility, monitoring robots without discomfort.

【Key Words】

Soft Robot, Soft Actuator, Soft Mechanism, Flexible Sensor, Biohybrid, Biocomputing

【Term of Project】 FY2018-2022

【Budget Allocation】 1,194,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://softrobot.jp

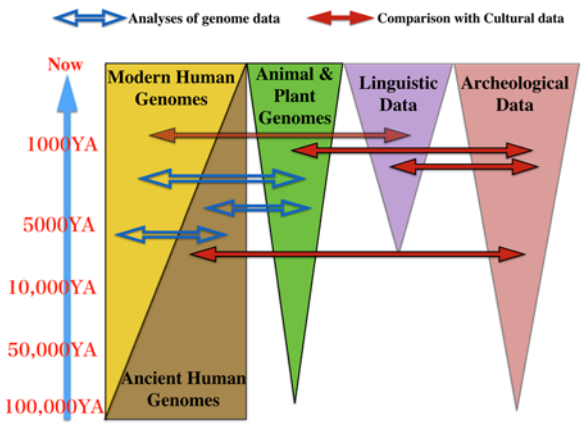
Title of Project : Deciphering Origin and Establishment of Japonesians mainly based on genome sequences date

Naruya Saitou
(National Institute of Genetics, Division of Population Genetics, Professor)

Research Project Number : 18H05505 Researcher Number : 30192587

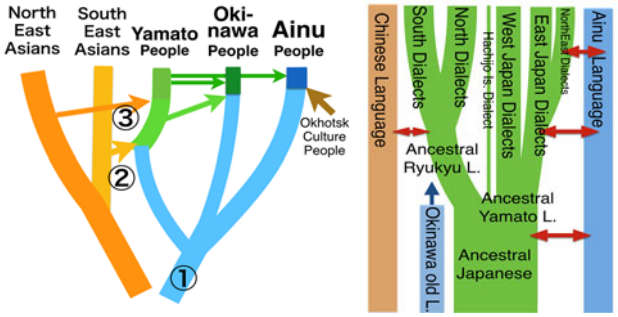
【Purpose of the Research Project】

People reached Yaponesia (Japanese Archipelago) around 40,000 years ago for the first time, and many waves of migration occurred after that time. Within this framework, we seek to decipher the genomic history of Yaponesians (people on Japanese Archipelago) through determination and comparative analyses of many modern and ancient human genomes. We also analyze genome data of animals and plants which moved to Yaponesia with Yaponesians. Temporal changes of population size are also estimated from genome sequence data by using existing methods and newly developed methods. Because we need to examine history of Yaponesians from many aspects, archeology with special reference to age estimation (dating) of artifacts and ancient organisms and linguistics with special reference to dialect analyses of Japanese and Ryukyuan languages will have collaborative fusion study with evolutionary genomics. We aim to establish new discipline, "genome history" of Yaponesians, through integration of these various analyses.



【Content of the Research Project】

Collect modern Yaponesian DNA samples from various geographical area, and examine the three-migration hypothesis by analyzing their genome sequences (A01 and B03 groups). Extract DNAs from ancient Yaponesian of archeological sites in various periods and area, and compare their genome sequences with modern ones including analyses on natural selection and disease related genomic changes (A02, A01, B03 groups). Analyze genome sequences of animal and plant species and use them for estimating timings of human migrations to Yaponesia and interactions with continental people (A03 and B03 groups). Examine artifacts found from archeological sites of various periods and area with special reference of



detailed dating (B01 and A02 groups). Examine dialect data of Japanese and Ryukyuan languages in detail and also infer phylogenetic relationship of Japanese by comparing genome data (B02, A01, A02, B03 groups). Develop new theories to estimate population size change and selection coefficient changes during very short time scale (B03, A01 groups). Study different area of interdisciplinary researches not covered by A01-A03 and B01-B03 groups in A04 and B04 publicly offered groups. We publish magazine "Yaponesian", as well as supporting global collaborations and assisting career development of young researchers.

【Expected Research Achievements and Scientific Significance】

Clarify periods and source populations of Yaponesia within the framework of Out-of-Africa dispersal of anatomically modern humans.
Clarify population size changes of Yaponesians and their ancestors and estimate major migration times.
Estimate locations and periods of migrants to Yaponesia.
Clarify correlations between arrivals of cultural elements and human migrations from comparison of archeological data and mutational changes of genomic DNA.
Estimate the rate of changes of languages spoken in Yaponesia and narrow down language family that may be phylogenetically closer to Japanese.

【Key Words】

Yaponesia, Japanese Archipelago, human evolution, genome, archeology, linguistics, human history

【Term of Project】 FY2018-2022

【Budget Allocation】 658,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://yaponesian.org/
come-together@yaponesian.org/

Title of Project : Elucidation of the strategies of mechanical optimization in plants toward the establishment of the bases for sustainable structure system

Taku Demura
(Nara Institute of Science and Technology, Graduate School of Science and Technology, Professor)

Research Project Number : 18H05484 Researcher Number : 40272009

【Purpose of the Research Project】

As environmental and population issues are worsening at the global level, efforts to build up a sustainable society are accelerating. The creation of a sustainable living space, in harmony with the surrounding environment, is one of society's most important endeavors, even in the fields of manufacturing, architectural design, and urban planning.

In recent years, approaches in engineering using biomimetics have been pursued. Additionally, studies on plant cell walls have demonstrated that plants are excellent structural systems that autonomously optimize their mechanical properties in response to various environmental factors.

Based on the above background, this research project aims to understand the mechanical optimization of plants on a multi-scale (molecular, cellular, tissue, and individual) level. Also, we aim to sublimate the mechanical optimization strategy of plants into new energy-saving / material-saving building designs, new material models, and to create a base for the next-generation of sustainable structural systems (Figure 1).

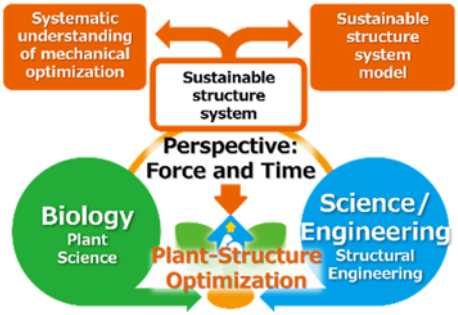


Figure 1. Research strategy and expected achievement

【Content of the Research Project】

In this area, we will create a foundation for a new principle of architectural structure system based on the "mechanical optimization strategies" hidden in various phenomena operated by plants. For this purpose, three research groups are set. Group A01 "System" will aim to understand the mechanical phenomenon at the organ-individual scale and will propose the new "building system". Group A02 "Module" will elucidate the mechanical phenomenon on the cell-tissue scale and will provide new module designs. Group A03 "Unit" will analyze the mechanical properties on the subcellular scale and will develop units (building materials) in construction.

【Expected Research Achievements and Scientific Significance】

One of the expected outcomes is the development of a new "structural system model" based on the mechanical optimization strategy of plants. We will thus utilize the knowledge of the structural-mechanical features that give plant cell walls their strength and plasticity to build up a next generation material model. It is also expected that "mechanical optimization" will be added to our knowledge of the growth strategies of plants, especially our insight into the fundamental principles for stable growth of organisms in harmony with the internal and external environments, which may rewrite the basic principles of biology. In addition, this research area is looking forward to the creation of a new scientific field that can directly contribute to the construction of a sustainable society. The academic achievement of this area will be relayed to social implementation technologies in the future. Particularly, we are expecting sustainable construction in harmony with various environmental factors unique to this country (earthquake, typhoon, temperature difference of the four seasons, etc.).

Furthermore, this research will contribute to the establishment of next-generation bio-based technologies, through the engineering of the functionalization of plant and their capabilities to respond to environmental stresses, thus generating plants that can withstand global environmental changes.

【Key Words】

Mechanical optimization: To change the body structure of living organisms into a mechanically optimized form during development and environmental response.
Sustainable structural system: A space structure with high sustainability even in exhaustion of resources and energy with constant changes in the environment.

【Term of Project】 FY2018-2022

【Budget Allocation】 1,180,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://bsw3.naist.jp/plant-structure-opt/

Title of Project : Molecular Engine: Design of Autonomous Functions through Energy Conversion

Kazushi Kinbara
(Tokyo Institute of Technology, School of Life Science and Technology, Professor)

Research Project Number : 18H05418 Researcher Number : 30282578

【Purpose of the Research Project】

In this research area, we define a molecular device that causes a mechanical structural change by receiving external energy and converts it into another form of energy, as "molecular engine." It is aimed at establishing basic scientific disciplines for building molecular engines. For this purpose, experts in synthetic chemistry, molecular biology, biophysics, soft matter physics, computer science, which have been developed independently as different fields, work together to unite wisdom and thereby create a new research field for nanoscale molecular devices and systems. Looking to construct social implementable devices, we explore the availability of various energy sources (Figs. 1 and 2).

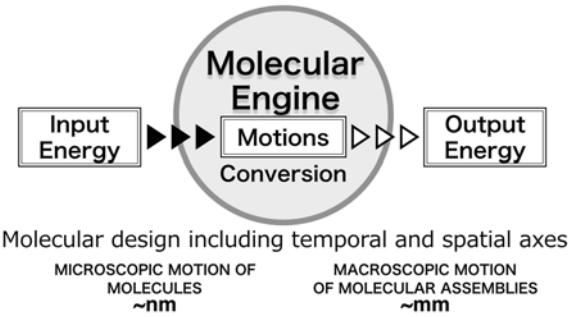


Fig. 1 Concept of “molecular engine.”

【Content of the Research Project】

In this area, in order to establish the concept of "molecular engine", small molecules with a relatively simple structure, macromolecules capable of forming a higher order structure such as a protein, molecular aggregates in which these are integrated. In each of the different hierarchies, we aim to construct disciplines to realize energy conversion via mechanical motion. For this purpose, the following four research groups are organized, including experimental, computational, and theoretical science with artificial molecular machines, biomolecular machines and molecular assemblies. A01: Rational design of molecular units for energy conversion, B01: Movement of molecular assemblies with energy conversion function, C01: Detection and measurement of molecular engines, C02: Theoretical analysis of energy conversion by molecular engines.

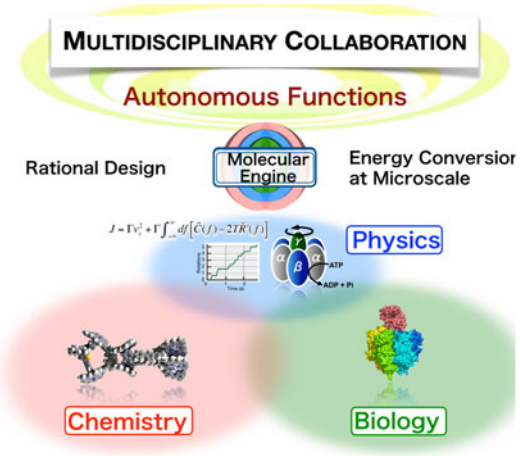


Fig. 2 Multidisciplinary collaboration.

【Expected Research Achievements and Scientific Significance】

Design principles for the energy conversion by the mechanical motion of molecular systems, that highly efficiently converts various energies such as chemical-bond, electrical, mechanical and, light energy to other usable energies is established. It is expected that new possibilities of energy conversion systems will be proposed.

【Key Word】

Molecular Machine: molecule that moves physically like a machine by applying external stimuli

【Term of Project】 FY2018-2022

【Budget Allocation】 1,193,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.molecular-engine.bio.titech.ac.jp

Title of Project : Singularity biology

Takeharu Nagai
(Osaka University, The Institute of Scientific and Industrial Research, Professor)

Research Project Number : 18H05408 Researcher Number : 20311350

【Purpose of the Research Project】

There exist critical moments, such as the 'Big Bang' where "something out of nothing gets created" or in the future, when artificial intelligence might become greater than human intelligence. These points are called *singularities*. In the field of biological science, discontinuous critical phenomena are broadly seen, for example, the emergence of life from the primordial soup, or the evolution and outbreak of diseases. It has been indicated that only a small number of core elements are required to bring about discontinuous changes to an entire multi-component system. However, the mechanism-of-action that generates such singularity phenomena is not yet certain. In our research project, to look deeply into singularity cells, we are developing an imaging platform that will achieve both wide field-of-view high-resolution imaging and high-speed long-term imaging, and corresponding information analysis methods. This will enable us to be at the cutting edge of new scientific fields, where we uncover the underlying mechanisms for the generation of singularity cells as well as their biological functions.

【Content of the Research Project】

In order to study the processes that singularity cells, considered as minority entities, bring criticality to an entire system (ex: an organ or whole body), it is necessary to measure, analyze, and examine such biological systems in a holistic spatial-temporal manner. For this purpose, an imaging system is required for visualization of *molecules, cells, and organs* across different length scales. In order to achieve this, we will organize a core team under a research management team to develop a unique machine we call **AMATERAS** (**A**spired **M**ultimodal **A**nalytical **T**ools for **E**very **R**are **A**ctivities in **S**ingularity) which allows us to capture macroscopic spatiotemporal dynamics with microscopic precision: *not only the composite trees but also the whole forest*. In addition, we will organize the following three groups to develop authentic trans-scale analysis that plays a role to *seamlessly link from micro to macro*. Group A01 will develop and integrate techniques to measure and control singularity cells from the stand point of optics and molecular engineering. Group A02 will construct a theoretical framework to identify singularity cells and to verify the causality based on information science. Group A03 will unravel the biological significance of singularity cells by verifying causality which is elicited from individual biological models. By conducting this kind of circulative collaborative research, we will create the research field "singularity biology", with reference to its universality.

【Expected Research Achievements and Scientific Significance】

We will develop an unprecedented integrative device for measurement and analysis, **AMATERAS**, and will establish a research platform covering not only academia but also several relevant companies. From the effective operation of **AMATERAS**, which includes the acceleration of large scale cross field research among optics, molecular engineering, mathematical biology, information science, biology, and medicine, we expect to largely contribute to the development of innovative devices, the construction of a new information processing theory, and early diagnosis to facilitate and intervention in the case of disease. By creating an alliance network with **AMATERAS** at its core, we will promote industry-academia collaborations. Moreover, this network will contribute to the development of human resources and foster next generation young leaders with full knowledge in different fields through holding international training courses and symposiums specializing in trans-scale measurements and analyses.

【Key Words】

Singularity phenomena: Phenomena that discontinuously and dramatically change the dynamics of an entire system in multi-cell society, where organs and individual bodies are constructed from large number of cells. We call the minority cells that trigger the changes "singularity cells".

【Term of Project】 FY2018-2022

【Budget Allocation】 1,210,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://singularity-bio.jp

List of the Continuing Projects for Grant-in-Aid for Scientific Research on Innovative Areas (Research in a proposed research area) of KAKENHI

Humanities and Social Sciences（ 6 Projects ）

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26101001	Kazuo Aoyama 70292464	Ibaraki University, Faculty of Humanities, Professor	Comparative Studies of Ancient American Civilizations	FY2014-2018	561,300
15H05964	Shinichi Nakamura 80237403	Kanazawa University, Faculty of Letters, Professor	Rice Farming and Chinese Civilization : Renovation of Integrated Studies of Rice-based Civilizations.	FY2015-2019	364,600
16H06546	Keiko Sakai 40401442	Chiba University, Faculty of Law, Politics and Economics, Professor	Establishing a New Paradigm of Social/ Human Sciences based on Relational Studies : in order to Overcome Contemporary Global Crisis	FY2016-2020	529,300
16H06407	Yoshihiro Nishiaki 70256197	The University of Tokyo, The University Museum, Professor	Cultural History of PaleoAsia -Integrative Research on the Formative Processes of Modern Human Cultures in Asia	FY2016-2020	664,800
17H06340	Masami K. Yamaguchi 50282257	Chuo University, Department of Psychology, Professor	Construction of the Face-Body studies in transcultural conditions	FY2017-2021	573,300
17H06334	Toyomi Asano 60308244	Waseda University, Faculty of Political Science and Economics, Professor	Creation of the study of reconciliation	FY2017-2021	243,100

Science and Engineering（ 30 Projects ）

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26102001	Takanori Fukushima 70281970	Tokyo Institute of Technology, Chemical Resources Laboratory, Professor	π-System Figuration: Control of Electron and Structural Dynamism for Innovative Functions	FY2014-2018	1,143,000
26103001	Yoshichika Otani 60245610	The University of Tokyo, Institute for Solid State Physics, Professor	Nano Spin Conversion Science	FY2014-2018	1,120,200
26104001	Kunio Inoue 10242166	Tohoku University, Research Center for Neutrino Science, Professor	Revealing the history of the universe with underground particle and nuclear research	FY2014-2018	1,122,800
26105001	Hiroshi Daimon 20126121	Nara Institute of Science and Technology, Graduate School of Materials Science, Professor	3D active site science	FY2014-2018	1,145,800
26106001	Ken Kurokawa 20343246	Tokyo Institute of Technology, Earth-Life Science Institute, Professor	Hadean Bioscience	FY2014-2018	1,079,400
26107001	Hiroshi Miyasaka 40182000	Osaka University, Graduate School of Engineering Science, Professor	Application of Cooperative Excitation into Innovative Molecular Systems with High-Order Photofunctions	FY2014-2018	961,100
26108001	Makoto Hashizume 90198664	Kyushu University, Graduate School of Medical Sciences, Professor	Multidisciplinary computational anatomy and its application to highly intelligent diagnosis and therapy	FY2014-2018	1,048,900
26109001	Yoshihisa Iio 50159547	Kyoto University, Disaster Prevention Research Institute, Professor	Crustal dynamics -Unified understanding of intra-island deformation after the great Tohoku-oki earthquake-	FY2014-2018	1,000,000

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05851	Norio Kawakami 10169683	Kyoto University, Graduate School of Science, Professor	Frontiers of materials science spun from topology	FY2015-2019	1,003,600
15H05795	Kazushi Mashima 70159143	Osaka University, Graduate School of Engineering Science, Professor	Precise Formation of a Catalyst Having a Specified Field for Use in Extremely Difficult Substrate Conversion Reactions	FY2015-2019	1,221,200
15H05866	Yoshiro Hirayama 20393754	Tohoku University, Graduate School of Science, Professor	Science of Hybrid Quantum Systems	FY2015-2019	1,045,300
15H05882	Hisatomo Harima 50211496	Kobe University Graduate School of Science, Professor	J-Physics: Physics of conductive multipole systems	FY2015-2019	1,173,100
15H05887	Hitoshi Murayama 20222341	The University of Tokyo, Kavli Institute for the Physics and Mathematics of the Universe, Project Professor	Why does the Universe accelerate? - Exhaustive study and challenge for the future -	FY2015-2019	1,106,000
15H05826	Taku Tsuchiya 70403863	Ehime University, Geodynamics Research Center, Professor	Interaction and Coevolution of the Core and Mantle: Toward Integrated Deep Earth Science	FY2015-2019	1,091,100
15H05835	Koichi Fukase 80192722	Osaka University, Graduate School of Science, Professor	Middle Molecular Strategy: Creation of Higher Bio-functional Molecules by Integrated Synthesis	FY2015-2019	1,108,100
15H05812	Kanya Kusano 70183796	Nagoya University, Solar-Terrestrial Environment Laboratory, Professor	Solar-Terrestrial Environment Prediction as Science and Social Infrastructure	FY2015-2019	649,400
16H06413	Hiroshi Fujioka 50282570	The University of Tokyo, Institute of Industrial Science, Professor	Materials Science and Advanced Electronics Created by Singularity	FY2016-2020	1,103,800
16H06508	Mitsuhiko Shionoya 60187333	The University of Tokyo, Graduate School of Science, Professor	Coordination Asymmetry: Design of Asymmetric Coordination Sphere and Anisotropic Assembly for the Creation of Functional Molecules	FY2016-2020	1,168,000
16H06488	Shoji Asai 60282505	The University of Tokyo, Graduate School of Science, Professor	New expansion of particle physics of post-Higgs era by LHC revealing the vacuum and space-time structure	FY2016-2020	1,017,400
16H06472	Kazushige Obara 40462501	The University of Tokyo, Earthquake Research Institute, Professor	Science of Slow Earthquakes	FY2016-2020	1,070,800
16H06442	Ikuro Abe 40305496	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	Creation of Complex Functional Molecules by Rational Redesign of Biosynthetic Machineries	FY2016-2020	1,106,300
16H06503	Hajime Ishihara 60273611	Osaka Prefecture University, Graduate School of Engineering, Professor	Nano-Material Manipulation and Structural Order Control with Optical Forces	FY2016-2020	1,049,900
16H06438	Hiroshi Kageyama 40302640	Kyoto University, Graduate School of Engineering, Professor	Synthesis of Mixed Anion Compounds toward Novel Functionalities	FY2016-2020	1,022,800
17H06454	Yasuhito Sekine 60431897	The University of Tokyo, Graduate School of Science, Associate Professor	Aqua planetology	FY2017-2021	1,079,400
17H06460	Motoko Kotani 50230024	Tohoku University, Graduate School of Science, Professor	Discrete Geometric Analysis for Materials Design	FY2017-2021	1,002,900
17H06366	Masako Kato 80214401	Hokkaido University, Faculty of Science, Professor	Soft Crystals: Science and Photofunctions of Flexible Response Systems with High Order	FY2017-2021	1,012,200

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06347	Itaru Hamachi 90202259	Kyoto University, Graduate School of Engineering, Professor	Chemistry for Miscellaneous Crowding Biosystems	FY2017-2021	1,215,500
17H06357	Takahiro Tanaka 40281117	Kyoto University, Graduate School of Sciences, Professor	Gravitational wave physics and astronomy: Genesis	FY2017-2021	1,079,000
17H06400	Hideaki Kakeya 00270596	Kyoto University, Graduate School of Pharmaceutical Sciences, Professor	Frontier research of chemical communications	FY2017-2021	1,108,700
17H06441	Motomu Kanai 20243264	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	Hybrid Catalysis for Enabling Molecular Synthesis on Demand	FY2017-2021	1,224,600

Biological Sciences（25 Projects）

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26110001	Masato Tanaka 00294059	Tokyo University of Pharmacy and Life Sciences, School of Life Sciences, Professor	Homeostatic Regulation by Various Types of Cell Death	FY2014-2018	953,900
26111001	Yasuo Mori 80212265	Kyoto University, Graduate School of Engineering, Professor	Oxygen biology: a new criterion for integrated understanding of life	FY2014-2018	1,176,200
26112001	Kazuto Kobayashi 90211903	Fukushima Medical University, School of Medicine, Professor	Mechanisms underlying the functional shift of brain neural circuitry for behavioral adaptation	FY2014-2018	1,213,600
26113001	Tetsuro Hirose 30273220	Hokkaido University, Institute for Genetic Medicine, Professor	Non-coding RNA neo-taxonomy	FY2014-2018	1,129,500
26114001	Yasuyuki Fujita 50580974	Hokkaido University, Institute for Genetic Medicine, Professor	Cell competition: a mechanism for survival of the fittest in the multi-cellular community	FY2014-2018	1,215,400
26115001	Atsushi Iwama 70244126	Chiba University, Graduate School of Medicine, Professor	Establishing a new paradigm of pathogenesis of the diseases through the understanding of stem cell aging	FY2014-2018	1,161,300
26116001	Hideki Taguchi 40272710	Tokyo Institute of Technology, Graduate School of Bioscience and Biotechnology, Professor	Nascent-chain biology	FY2014-2018	1,221,800
26117001	Gen Sobue 20148315	Nagoya University, Graduate School of Medicine, Professor	Brain Protein aging and Dementia Control	FY2014-2018	1,169,100
15H05897	Makoto Arita 80292952	RIKEN, Center for Integrative Medical Sciences, Team Leader	Quality of lipids in biological systems	FY2015-2019	1,180,100
15H05927	Makoto Tominaga 90260041	National Institutes of Natural Sciences, Okazaki Institute for Integrative Bioscience, Professor	Integrative understanding of biological phenomena with temperature as a key theme	FY2015-2019	1,171,100
15H05970	Katsuhiko Shirahige 90273854	The University of Tokyo, Institute of Molecular and Cellular Biosciences, Professor	Chromosome Orchestration System	FY2015-2019	1,146,200
15H05947	Atsushi Miyawaki 80251445	RIKEN, Brain Science Institute, Laboratory Head	Resonance Biology for Innovative Bioimaging	FY2015-2019	1,198,000

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05856	Shigeru Kondo 10252503	Osaka University, Graduate School of Frontier Biosciences, Professor	Discovery of the logic that establishes the 3D structure of organisms	FY2015-2019	1,102,300
15H05955	Toshinori Kinoshita 50271101	Nagoya University, Institute of Transformative Bio-Molecules, Professor	Integrative system of autonomous environmental signal recognition and memorization for plant plasticity	FY2015-2019	1,184,500
16H06552	Jun Minagawa 80280725	National Institutes of Natural Sciences, National Institute for Basic Biology, Professor	New Photosynthesis : Re-optimization of the solar energy conversion system	FY2016-2020	1,057,500
16H06455	Kazuo Emoto 80300953	The University of Tokyo, Department of Biological Sciences, Professor	Dynamic regulation of brain function by scrap & build system	FY2016-2020	1,179,100
16H06479	Ryoichiro Kageyama 80224369	Kyoto University, Institute for Virus Research, Professor	Interplay of developmental clock and extracellular environment in brain formation	FY2016-2020	1,181,800
16H06495	Mitsuru Matsumoto 60221595	Tokushima University, Institute for Enzyme Research, Professor	Creation, function and structure of neo-self	FY2016-2020	1,064,600
16H06429	Yoshihiro Kawaoka 70135838	The University of Tokyo, Institute of Medical Science, Professor	Neo-virology: the raison d'etre of viruses	FY2016-2020	1,061,100
16H06464	Tetsuya Higashiyama 00313205	Nagoya University, Institute of Transformative Bio-molecules, Professor	Determining the principles of the birth of new plant species: molecular elucidation of the lock-and-key systems in sexual reproduction	FY2016-2020	1,208,400
17H06299	Shinya Kuroda 50273850	The University of Tokyo, Graduate School of Science, Professor	Transomic Analysis of Metabolic Adaptation	FY2017-2021	1,224,700
17H06384	Shigeru Kuratani 00178089	RIKEN, Chief Scientist	Evolutionary theory for constrained and directional diversities	FY2017-2021	1,230,800
17H06470	Masaaki Umeda 80221810	Nara Institute of Science and Technology, Graduate School of Biological Sciences, Professor	Principles of pluripotent stem cells underlying plant vitality	FY2017-2021	1,166,500
17H06413	Shigeomi Shimizu 70271020	Tokyo Medical and Dental University, Medical Research Institute, Professor	Toward an integrative understanding of functional zones in organelles	FY2017-2021	1,214,600
17H06423	Makoto Tachibana 80303915	Tokushima University, Institute of Advanced Medical Sciences, Professor	Spectrum of the Sex: a continuity of phenotypes between female and male	FY2017-2021	1,144,600

Interdisciplinary Area（ 20 Projects ）

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26118001	Kazuhiro Ueda 60262101	The University of Tokyo, Graduate School of Arts and Sciences, Professor	Cognitive Interaction Design: A Model-Based Understanding of Communication and its Application to Artifact Design	FY2014-2018	668,400
26119001	Daisuke Kohda 80186618	Kyushu University, Medical Institute of Bioregulation, Professor	Novel measurement techniques for visualizing 'live' protein molecules at work	FY2014-2018	1,171,000
26120001	Jun Ota 50233127	The University of Tokyo, Research into Artifacts, Center for Engineering (RACE), Professor	Understanding brain plasticity on body representations to promote their adaptive functions	FY2014-2018	1,059,400

Research Project Number	Head Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05907	Satoru Miyano 50128104	The University of Tokyo, The Institute of Medical Science, Professor	Conquering Cancer through Neo-dimensional Systems Understanding	FY2015-2019	1,101,600
15H05817	Ichiro Yasuda 80270792	The University of Tokyo, Atmosphere and Ocean Research Institute, Professor	Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem	FY2015-2019	1,112,600
15H05871	Atsushi Nambu 80180553	National Institute for Physiological Sciences, Division of System Neurophysiology, Professor	Non-linear Neuro-oscillology: Towards Integrative Understanding of Human Nature	FY2015-2019	1,149,700
15H05935	Satoshi Furukawa 20726260	Japan Aerospace Exploration Agency, Head of Space Biomedical Research Group, Astronaut	“LIVING IN SPACE” - Integral Understanding of life-regulation mechanism from “SPACE”	FY2015-2019	1,172,900
15H05914	Shin’ya Nishida 20396162	Nippon Telegraph and Telephone Corp, Human Information Science Lab, NTT Communication Science Laboratories, Senior Distinguished Scientist	Understanding human recognition of material properties for innovation in SHITSUKAN science and technology	FY2015-2019	1,086,200
16H06395	Kiyoto Kasai 80322056	The University of Tokyo, Department of Neuropsychiatry, Professor	Science of personalized value development through adolescence: integration of brain, real-world, and life-course approaches	FY2016-2020	1,112,800
16H06524	Noriko Osumi 00220343	Tohoku University School of Medicine, Professor	Integrative Research toward Elucidation of Generative Brain Systems for Individuality	FY2016-2020	1,153,000
16H06535	Koichi Hashimoto 80228410	Tohoku University, Graduate School of Information Sciences, Professor	Systems Science of Bio-Navigation	FY2016-2020	1,087,100
16H06573	Mutsuhiro Takekawa 30322332	The University of Tokyo, The Institute of Medical Science, Professor	Integrative understanding of biological signaling networks based on mathematical science	FY2016-2020	1,022,900
16H06561	Kenji Doya 80188846	Okinawa Institute of Science and Technology Graduate University, Neural Computation Unit, Professor	Correspondence and Fusion of Artificial Intelligence and Brain Science	FY2016-2020	1,119,100
16H06400	Takeshi Sakurai 60251055	University of Tsukuba, Faculty of Medicine, Professor	Creation and Promotion of the Will-Dynamics	FY2016-2020	1,153,800
17H06391	Kouji Matsushima 50222427	The University of Tokyo, Graduate School of Medicine, Professor	Preventive medicine through inflammation cellular sociology	FY2017-2021	1,195,200
17H06316	Kenji Kawamura 90431478	National Institute of Polar Research, Division for Research and Education, Associate Professor	Giant reservoirs of heat/water/material : Global environmental changes driven by the Southern Ocean and the Antarctic Ice Sheet	FY2017-2021	1,156,200
17H06378	Kazuo Okanoya 30211121	The University of Tokyo, Graduate School of Arts and Sciences, Professor	Studies of Language Evolution for Co-creative Human Communication	FY2017-2021	1,078,400
17H06324	Naoya Fujita 20280951	Japanese Foundation for Cancer Research, The Cancer Chemotherapy Center, Center Director	Integrated analysis and regulation of cellular diversity	FY2017-2021	1,189,600
17H06308	Haruhiko Bito 00291964	The University of Tokyo, Graduate School of Medicine, Professor	Brain information dynamics underlying multi-area interconnectivity and parallel processing	FY2017-2021	1,235,600
17H06433	Jian-Ren Shen 60261161	Okayama University, Research Institute for Interdisciplinary Science, Professor	Creation of novel light energy conversion system through elucidation of the molecular mechanism of photosynthesis and its artificial design in terms of time and space	FY2017-2021	1,146,100

Grant-in-Aid for Scientific Research (S)

☐ Distribution of the Newly Adopted Projects

Purpose and Character of Grant-in-Aid for Scientific Research (S) (excerpt from the "Application Procedures for Grants-in-Aid for Scientific Research-KAKENHI-"):

1) **Funding target:**
Research plan conducted by a single or a relatively small number of researchers that aims at achieving a major development in creative and pioneering research

2) **Range of total budget:**
50 million yen to 200 million yen

3) **Research period:**
5 years as a general rule

【 New Projects 】

	Number of Applications			Total Grant Disbursements (FY2018)	Per-project Grants (FY2018)	
	Received	Adopted	Ratio		Average	Largest
			(%)	(Thousands of Yen)	(Thousands of Yen)	(Thousands of Yen)
Total	704	79	11.2	3,215,800	40,706	105,100

【 New and Ongoing Projects 】

	Number of Applications	Total Grant Disbursements (FY2018)	Per-project Grants (FY2018)	
			Average	Largest
		(Thousands of Yen)	(Thousands of Yen)	(Thousands of Yen)
Total	413	11,819,600	28,619	105,100

※ Figure reflects only direct funding

List of the Newly Adopted Projects for Grant-in-Aid for Scientific Research (S) of KAKENHI, FY2018

○ Broad Section A（6 Projects） (Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05216	Yoshiyuki Tamura 20197586	Hokkaido University, Graduate School of Law, Professor	Cross-Sectional Review of Intellectual Property Laws from the Viewpoint of Fostering and Securing Public Domain	FY2018-2022	21,200 / 110,700
18H05217	Tsutomu Watanabe 90313444	The University of Tokyo, Graduate School of Economics, Professor	Central Bank Communication Design	FY2018-2022	33,000 / 144,500
18H05218	Yasushi Kato 90183780	Hitotsubashi University, Graduate School of Social Sciences, Professor	Towards a global standard of dignity as a philosophical concept: theoretical approaches, conceptual histories, and cross-cultural comparisons	FY2018-2022	24,600 / 130,500
18H05219	Takumi Ikeda 90259250	Kyoto University, Institute for Research in Humanities, Professor	A Study on the historical Development of the Sino-Tibetan Languages and their Typological Geography	FY2018-2022	27,900 / 130,400
18H05220	Yoshifumi Ikeda 40150627	University of the Ryukyus, Faculty of Global and Regional Studies, Professor	The Interdisciplinary Study regarding Conserving and Utilize Methods of the Mongol Shipwrecks	FY2018-2020	42,100 / 82,600
18H05221	Hajime Baba 70332195	National Institutes for Cultural Heritage, Nara National Research Institute for Cultural Properties, Department of Imperial Palace Sites Investigations, History Section, Chief	Development of Integrated Knowledge through Establishment of an Interactive Research Scheme based on the Open-Data of Research Resources for Wooden Tablets and Related Topics	FY2018-2022	15,200 / 96,100

○ Broad Section B（15 Projects） (Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05222	Satoshi Yamamoto 80182624	The University of Tokyo, Graduate School of Science, Professor	Chemical Composition of Disk Forming Regions of Solar-type Protostars and its Evolution to Planetary Systems	FY2018-2022	24,800 / 144,500
18H05223	Mamoru Doi 00242090	The University of Tokyo, Graduate School of Science, Professor	Identifying the origin of the type-Ia supernova by observations just after the explosion	FY2018-2022	35,600 / 147,400
18H05224	Hiroyuki Kagi 70233666	The University of Tokyo, Graduate School of Science, Professor	Material Science of Hydrogen in the deep earth and planets	FY2018-2022	51,100 / 148,500
18H05225	Kazushi Kanoda 20194946	The University of Tokyo, Graduate School of Engineering, Professor	Creation of a new discipline, quantum glass, for electronic systems and its development to material science	FY2018-2022	62,200 / 151,400
18H05226	Toru Iijima 80270396	Nagoya University, Center for Experimental Studies, Professor	Search for new symmetry violation in leptons	FY2018-2022	40,800 / 147,400
18H05227	Yuji Matsuda 50199816	Kyoto University, Graduate School of Science, Professor	Rotational Symmetry Breaking in Strongly Correlated Quantum Matters	FY2018-2022	74,500 / 152,500

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05228	Yoshiro Takahashi 40226907	Kyoto University, Graduate School of Science, Professor	Exploration of new quantum condensed phase by exploiting orbital and spin degrees of freedom of ultracold atomic gases in an optical lattice	FY2018-2022	37,600	144,600
18H05229	Masaaki Sugiyama 10253395	Kyoto University, Institute for Integrated Radiation and Nuclear Science, Professor	Neutron Structural Biology for New Generation	FY2018-2022	69,400	151,600
18H05230	Kichiji Hatanaka 50144530	Osaka University, Research Center for Nuclear Physics, Specially Appointed Professor	Search for the neutron electric dipole moment and the time reversal violation	FY2018-2022	72,500	152,200
18H05231	Yoshitaka Kuno 30170020	Osaka University, Graduate School of Science, Professor	New Initiative on Search for Charged Lepton Flavor Violation with Highly Intense Muon Source	FY2018-2022	36,500	148,500
18H05232	Tomoaki Kubo 40312540	Kyushu University, Faculty of Science, Professor	Experimental study on syn-deformational reaction processes at high pressures: Implications for slab weakening and deep earthquakes	FY2018-2022	68,800	108,400
18H05233	Kenichi Bannai 90343201	Keio University, Faculty of Science and Technology, Professor	Strategic research to construct motivic units using new symmetry	FY2018-2022	17,900	91,900
18H05234	Yukio Katsukawa 00399289	National Institutes of Natural Sciences, National Astronomical Observatory of Japan, Solar Science Observatory, Associate Professor	High Precision Polarimetric Observation by a Balloon-Borne Solar Telescope: Revealing Conversion Processes of Magnetic Energy in the Stellar Atmosphere	FY2018-2022	36,500	109,100
18H05235	Satoshi Yokkaichi 20360670	RIKEN, Nishina Center, Senior Research Scientist	Origin of hadron mass studied by the systematic measurement of spectral change of mesons in nuclei	FY2018-2022	55,900	150,800
18H05236	Tetsuo Hatsuda 20192700	RIKEN, Interdisciplinary Theoretical and Mathematical Sciences, Program Director	From Quarks to Neutron Stars: Challenges in QCD	FY2018-2022	14,300	91,600

○ Broad Section C （ 9 Projects ）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05237	Akihisa Tomita 60501434	Hokkaido University, Graduate School of Information Science and Technology, Professor	Information communication technology ensuring the long term security over a century	FY2018-2022	24,700	148,200
18H05238	Shinji Yamashita 40239968	The University of Tokyo, Research Center for Advanced Science and Technology, Professor	Study on digital frontier photonic sensing based on omnipotent fiber lasers	FY2018-2022	38,000	144,800
18H05239	Tsuyoshi Ichimura 20333833	The University of Tokyo, Earthquake Research Institute, Associate Professor	Development of crust imaging enhanced by hetero-computing for reducing earthquake disaster	FY2018-2022	49,200	144,700
18H05240	Shoji Kawahito 40204763	Shizuoka University, Research Institute of Electronics, Professor	Ultimately-Time-Resolved Imaging Devices Using Ultrafast Hybrid Cascade Photo-Charge Modulators and Their Applications	FY2018-2022	33,500	147,600
18H05241	Takayuki Kitamura 20169882	Kyoto University, Graduate School of Engineering, Professor	Design on Mechanical and Multi-Physics Properties of Nano-Structured Meta-Interface	FY2018-2022	58,800	150,700

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05242	Satoyuki Kawano 00250837	Osaka University, Graduate School of Engineering Science, Professor	Dynamical flow control of nanoparticles by machine learning and its application to single molecule identification technologies	FY2018-2022	26,800	119,000
18H05243	Takeshi Yanagida 50420419	Kyushu University, Institute of Material Chemistry and Engineering, Professor	Fundamental Study of Robust Molecule Recognition Electronics	FY2018-2022	47,300	150,200
18H05244	Atsushi Ishiyama 00130865	Waseda University, Graduate School of Science and Engineering, Professor	Establishment of design principle and basic technology for next generation medical high temperature superconducting skeleton-cyclotron	FY2018-2022	31,400	148,800
18H05245	Hirotaka Terai 10359094	National Institute of Information and Communications Technology, Advanced ICT Research Institute, Executive Researcher	Development of new imaging technology based on superconducting single-photon camera	FY2018-2022	37,600	149,400

○ Broad Section D （ 12 Projects ）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05246	Koki Takanashi 00187981	Tohoku University, Institute for Materials Research, Professor	Renaissance of Metallic Superlattices	FY2018-2022	54,800	150,900
18H05247	Keiichi Tomishige 50262051	Tohoku University, Graduate School of Engineering, Professor	Design and development of novel active sites on heterogeneous catalysts using direct interaction of molecules with solid surfaces	FY2018-2022	41,700	146,900
18H05248	Satoshi Awaji 10222770	Tohoku University, Institute for Materials Research, Professor	Magnet technology development for 50T cryogen-free high temperature superconducting magnet	FY2018-2021	11,900	146,100
18H05249	Tetsu Ichitsubo 40324826	Tohoku University, Institute for Materials Research, Professor	Construction of new mechanism for dual-ion storage batteries concerted by lithium and multivalent ions	FY2018-2022	76,800	152,800
18H05250	Jiro Itatani 50321724	The University of Tokyo, the Institute for Solid State Physics, Associate Professor	Evolution of Attosecond Science by Next-generation Ultrashort-pulse Lasers	FY2018-2022	54,000	150,300
18H05251	Michikazu Hara 70272713	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Low temperature ammonia synthesis by heterogeneous catalysts enhancing electron-donating power	FY2018-2022	42,000	146,600
18H05253	Yukio Takahashi 00415217	Osaka University, Graduate School of Engineering, Associate Professor	Creation of platform for the next generation synchrotron radiation microspectroscopy by multi-dimensional X-ray ptychography	FY2018-2022	21,600	136,400
18H05254	Takayoshi Nakano 30243182	Osaka University, Graduate School of Engineering, Professor	“Materials Science of Anisotropy” for induction of bone tissue anisotropy	FY2018-2022	32,300	148,800
18H05255	Masahiro Tatsumisago 50137238	Osaka Prefecture University, Graduate School of Engineering, Professor	Dynamics of Composite Electrodes in All-Solid-State Ionics Devices	FY2018-2022	78,400	143,400
18H05256	Kei Ameyama 10184243	Ritsumeikan University, College of Science and Engineering, Professor	Clarification of innovative deformation mechanism in harmonic structure materials and creation of design principle for structure materials for next generation	FY2018-2022	105,100	155,000

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05257	Yousoo Kim 50373296	RIKEN, Cluster for Pioneering Research, Chief Scientist	Scanning tunneling microscopy for the development of ultimate nano-optics	FY2018-2022	54,200	150,600
18H05258	Akira Fujiwara 70393759	NTT Basic Research Laboratories, Physical Science Laboratory, Senior Distinguished Scientist	Quantum Standards and Ultimate Precision Measurements Based on Single Electrons	FY2018-2022	78,600	151,400

○ Broad Section E（7 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05259	Kyoko Nozaki 60222197	The University of Tokyo, Graduate School of Engineering, Professor	Catalytic Bond-Cleavage Reactions toward Utilization of Renewable Resources	FY2018-2022	21,400	147,900
18H05260	Takuzo Aida 00167769	The University of Tokyo, Graduate School of Engineering, Professor	Multiscale Interfacial Molecular Science for Innovative Functional Materials	FY2018-2022	32,000	148,800
18H05261	Shigehiro Yamaguchi 60260618	Nagoya University, Institute of Transformative Bio-Molecules, Professor	Chemistry of Boron-Containing π-Electron Materials	FY2018-2022	39,500	149,000
18H05262	Susumu Kitagawa 20140303	Kyoto University, Institute for Advanced Study, Institute for Integrated Cell-Material Sciences, Distinguished Professor	Chemistry of Adaptable Space	FY2018-2022	40,000	149,500
18H05263	Jiro Abe 70211703	Aoyama Gakuin University, College of Science and Engineering, Professor	Creative Research and Development of Incoherent Nonlinear Photoswitchable Molecules	FY2018-2022	42,400	149,700
18H05264	Hiromi Nakai 00243056	Waseda University, Faculty of Science and Engineering, Professor	Clarification of Ubiquitous Proton Function in Photoreceptive Proteins by Quantum Molecular Dynamics Simulations	FY2018-2022	59,400	151,100
18H05265	Tahei Tahara 60217164	RIKEN, Cluster for Pioneering Research, Chief Scientist	Exploring Interface Science by Concerted Use of Advanced Spectroscopy and Theory	FY2018-2022	27,800	148,400

○ Broad Section F（4 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05266	Tadao Asami 90231901	The University of Tokyo, Graduate School of Agricultural and Life Sciences, Professor	Development of basic technology of chemistry and biology for reducing damage by root parasitic weeds	FY2018-2022	64,000	151,600
18H05267	Kazushige Touhara 00280925	The University of Tokyo, Graduate School of Agricultural and Life Sciences, Professor	Identification of primer pheromones in mammals and elucidation of a neural basis for the pheromone action	FY2018-2022	19,200	147,600
18H05268	Kenji Matsuura 40379821	Kyoto University, Graduate School of Agriculture, Professor	Antiaging system of long-lived termite kings	FY2018-2022	46,300	149,600
18H05269	Kazumitsu Ueda 10151789	Kyoto University, Graduate School of Agriculture, Professor	Uncovering the secrets of lipid-transporting ABC proteins	FY2018-2022	35,100	148,900

○ Broad Section G（7 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05270	Hiroki R. Ueda 20373277	The University of Tokyo, Graduate School of Medicine, Professor	Designing the mammalian biological oscillators	FY2018-2022	94,300 / 154,100
18H05271	Yukihide Tomari 90447368	The University of Tokyo, Institute for Quantitative Biosciences, Professor	Biochemical approaches to understanding the reaction platforms of the piRNA pathway	FY2018-2022	34,700 / 148,900
18H05272	Tsutomu Suzuki 20292782	The University of Tokyo, Graduate School of Engineering, Professor	Dynamic regulation of RNA modification and biological process	FY2018-2022	41,400 / 149,800
18H05273	Kentaro Arikawa 20167232	SOKENDAI – The Graduate University for Advanced Studies, School of Advanced Sciences, Professor	Spectral opponency in photoreceptors : neuroethological analysis	FY2018-2022	91,800 / 154,000
18H05274	Yoshikatsu Matsubayashi 00313974	Nagoya University, Graduate School of Science, Professor	Molecular dissection of peptide signaling in plants	FY2018-2022	25,300 / 148,100
18H05275	Akihiko Nakano 90142140	RIKEN Center for Advanced Photonics, Deputy Director	Full elucidation of sorting mechanisms in and around the Golgi apparatus by super-resolution live imaging	FY2018-2022	24,000 / 148,300
18H05276	Tatsuya Hirano 50212171	RIKEN, Cluster for Pioneering Research, Chief Scientist	Molecular mechanisms of condensins I and II	FY2018-2022	32,000 / 148,800

○ Broad Section H（3 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05277	Takaaki Akaike 20231798	Tohoku University, Graduate School of Medicine, Professor	Sulfur-mediated energy metabolism, sulfur respiration: Its discovery and physiological functions	FY2018-2022	40,500 / 148,700
18H05278	Osamu Takeuchi 10379092	Kyoto University, Institute for Frontier Life and Medical Sciences, Professor	Analysis of immune regulatory mechanisms mediated by mRNA metabolism	FY2018-2022	32,000 / 148,900
18H05279	Hisashi Arase 10261900	Osaka University, Research Institute for Microbial Diseases, Professor	Studies on the regulation of infection and immunity via paired receptors	FY2018-2022	32,000 / 148,800

○ Broad Section I（8 Projects）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget / Budget throughout for the Entire Research Period
18H05280	Hiroshi Kiyono 10271032	The University of Tokyo, The Institute of Medical Science, Distinguished Professor	Multi Regulatory System for Gut Homeostasis and Inflammation	FY2018-2022	31,100 / 147,200
18H05281	Takashi Shinohara 30322770	Kyoto University, Graduate School of Medicine, Professor	Molecular Analysis of Spermatogonial Stem Cell Aging	FY2018-2022	32,000 / 148,800
18H05282	Atsushi Kumanogoh 10294125	Osaka University, Graduate School of Medicine, Professor	Investigation on pathological implications of guidance molecules in neuro-immune-metabolism	FY2018-2022	31,800 / 147,800

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05283	Toshihisa Komori 00252677	Nagasaki University, Graduate School of Biomedical Sciences, Professor	Elucidation of the mechanism in the regulation of chondrocyte-specific Runx2 enhancer and development of the drug for osteoarthritis	FY2018-2022	32,500	148,800
18H05284	Toshio Suda 60118453	Kumamoto University, International Research Center for Medical Sciences, Distinguished Professor	Self-Renewal Capacity of Hematopoietic Stem Cells through the Regulation of Mitochondrial Metabolism	FY2018-2022	28,000	140,000
18H05285	Kazuhiko Yamamoto 80191394	RIKEN, Center for Integrative Medical Sciences, Deputy Director	Establishment of a novel strategy for pathological analysis of multifactorial diseases using genetic risk variants	FY2018-2022	32,000	148,800
18H05286	Kazuyo Moro 90468489	RIKEN, Center for Integrative Medical Sciences, Team leader	Role of ILC2 in idiopathic interstitial pneumonia	FY2018-2022	30,900	148,200
18H05287	Yukio Nishimura 20390693	Tokyo Metropolitan Institute of Medical Science, Department of Dementia and Higher Brain Function, Neural Prosthesis Project, Project Leader	Neural Mechanisms of Functional Recovery via Artificial Neural Connection	FY2018-2022	41,600	113,200

○ Broad Section J （ 4 Projects ）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05288	Masato Motomura 90574286	Hokkaido University, Graduate School of Information Science and Technology, Professor	Innovative Self-Learnable Architecture Platform for Accelerating Intelligent Computing	FY2018-2022	25,900	148,300
18H05289	Kazuo Sakiyama 80508838	The University of Electro-Communications, Graduate School of Informatics and Engineering, Professor	Resilience Enhancement of IoT Ecosystem by Cryptographic Technologies	FY2018-2022	38,800	149,500
18H05290	Masanobu Taniguchi 00116625	Waseda University, Graduate School of Science and Engineering, Professor	Introduction of general causality to various observations and the innovation for its optimal statistical inference	FY2018-2022	23,000	140,600
18H05291	Ken-ichi Kawarabayashi 40361159	Research Organization of Information and Systems, National Institute of Informatics, Principles of Informatics Research Division, Professor	Large Graphs: Theory and Algorithms	FY2018-2022	27,000	148,500

○ Broad Section K （ 4 Projects ）

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05292	Yoshinori Iizuka 40370043	Hokkaido University, Institute of Low Temperature Science, Assistant Professor	Construction of world's most reliable deposited-aerosol database on the Anthropocene (from 1850 to 2020)	FY2018-2022	12,100	147,000
18H05293	Yoshito Kumagai 00250100	University of Tsukuba, Faculty of Medicine, Professor	Environmental electrophiles exposome and reactive sulfur species as its regulator molecule	FY2018-2022	48,500	150,200
18H05294	Shuji Fujita 30250476	Research Organization of Information and Systems, National Institute of Polar Research, Professor	Study on physics and layers of ice cores containing information of climate change over the past 720 k-years, and study on the "oldest ice"	FY2018-2022	12,400	88,600

(Thousands of Yen)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Annual Budget	Budget throughout for the Entire Research Period
18H05295	Yoichi Kamagata 70356814	National Institute of Advanced Industrial Science and Technology (AIST) , Bioproduction Research Institute, Senior Researcher	Methanogenesis from root organic matters in deep subsurface	FY2018-2022	32,000	148,800

Title of Project : Cross-Sectional Review of Intellectual Property Laws from the Viewpoint of Fostering and Securing Public Domain

Yoshiyuki Tamura
(Hokkaido University, Graduate School of Law, Professor)

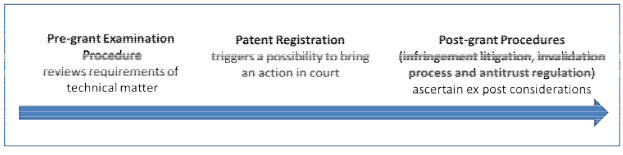
Research Project Number : 18H05216 Researcher Number : 20197586
Keyword : Intellectual Property, Public Domain, Patent, Copyright, Trademark

【Purpose and Background of the Research】

In the world of conventional intellectual property law studies, contrary to many concepts of intellectual creations and creators which are placed at the core of intellectual property, public domain is rarely at the spotlight, beyond being negatively defined as unsuitable object of intellectual property rights. However, as the intellectual property law encourages creation and aims to develop industries and culture, its ultimate goals should be to enrich public domain and to allow enjoying its use by the public, and the creators' right to their creations should be only a means to realize it. This research thus aims at constructing a public-domain-centered intellectual property law from the viewpoint of enriching public domain and ensuring its use.

【Research Methods】

With respect to disputes on the boundaries of public domain, there are limits to applying all-or-nothing methodology to granting rights upon the satisfaction of their subsistence requirements. Therefore, the intellectual property rights, being action regulations, establish a general methodology for solving by processes connected to dealing with each scenario of right subsistence, protection scope, remedies and the like by the approach realizing desirable behavior regulations through appropriately judging various relevant circumstances by a particular institution in a series of processes leading from the right subsistence, through decision on infringement, to remedies.



【Expected Research Achievements and Scientific Significance】

Intellectual property rights, as opposed to property rights towards tangible things, are easy to become the object of lobbying due to the high degree of freedom in system design with regard to what kind of action can be regulated. As the nature of the right, which allow a small number of rightholders to regulate the uses of numerous individuals, produces considerable benefits to rightholders, while the users' benefits, contrary to the rightholders' ones, tend to be dispersed and small, the intentions of the rightholders enthusiastic in lobbying are strongly reflected in policy making, and thus the rights tend to be excessively strengthened (minoritarian bias). However, the conventional arguments starting with intellectual creations and creators work in a direction to rather promote this bias.

This research, which places into the center the position of seeking to foster and secure public domain as the purpose of intellectual property rights, has significance in providing the foundation for overcoming such bias of policy making by arguing for setting the position of those, for whom it is hard to participate in the policy making processes, as default for mind setting.

【Publications Relevant to the Project】

・Yoshiyuki Tamura, "Muddling Through" of Patent System Towards Innovation (1)-(5), IPLP J. Vol. 35, 27-50, Vol. 36, 153-179, Vol. 39, 293-315 (2011-2012), Vol. 46, 269-292 (2015), Vol. 50, 175-254 (2018)
・Yoshiyuki Tamura, Thinking about the Menu of Regulations on Exploiting Copyrighted Materials, 42 Copyright Law Journal 22-68 (2016)
・Yoshiyuki Tamura, Copyright Reform in Japan: An Analysis of "Structural Problems" in the Digitized and Internet Age, 44 IPLP J. 25-140 (2014)

【Term of Project】 FY2018-2022

【Budget Allocation】 110,700 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.juris.hokudai.ac.jp/riilp/
http://lex.juris.hokudai.ac.jp/~ytamura/

Title of Project：Central Bank Communication Design

Tsutomu Watanabe
(The University of Tokyo, Graduate School of Economics, Professor)

Research Project Number：18H05217　Researcher Number: 90313444
Keyword：Macroeconomics, game theory, central banks, monetary policy, transparency, credibility, attention

【Purpose and Background of the Research】

Central banking is undergoing a major shift from secretiveness to active information disclosure. However, there is no academic consensus on the best way for central banks to communicate with the private sector, so that individual central banks have had to use trial and error, leading to economic instability as epitomized by the global economic crisis following the Lehman shock. Against this background, the aim of this research project is to empirically examine whether central bank communication has been able to gain the attention of and credibility with consumers, businesses, and investors, and if not, why this is the case. Moreover, using macroeconomic and game theory, we aim to construct models in which, under a setting in which the acquisition and processing of information is costly, the type of information that people obtain (what they pay attention to) and its accuracy (how much attention they pay) is endogenously determined, in order to examine the determinants of public attention to messages from central banks. Based on the theoretical and empirical results, we then aim to design a central bank communication system that helps to raise economic welfare.

【Research Methods】

The work to examine central bank communication is organized into four groups. The Theoretical Models Group conducts model analyses using both macroeconomic and game theory. The Survey Group examines the response of consumers and businesses to central bank signals and the causes of such response (or lack of it). The Unstructured Data Group explores the current state of central bank-private sector communication using textual information such as policy decision documents and governor speeches released by central banks. The Case Study Group will conduct case studies on information transmission focusing on communication by the Bank of Japan from 2000 onward.

The topic of this research is communication between the central bank and the private sector, and communication takes the form of documents, speeches, and statements, so that it is necessary to convert such unstructured data into a manageable form to analyze it. Specifically, we will construct three types of datasets consisting of (1) written information released by central banks, (2) central bank-related written information released by economic news agencies such as Bloomberg, (3) and central bank-related written information released by financial institutions, and apply text mining techniques such as LDA (Latent Dirichlet Allocation) to them.

【Expected Research Achievements and Scientific Significance】

As the first country worldwide to grapple with the zero lower bound on nominal interest rates and the attendant policy challenges, Japan has been forced to undertake much trial and error in central bank communication. Using Japan's experience as a rich case study, this research project seeks to gain universal academic insights on central bank communication in order to share them worldwide. A famous example where academic insights have led to real-world institutional changes is central bank independence, and the aim of this project is to make a similar contribution to central bank transparency.

【Publications Relevant to the Project】

[1] "Novel and Topical Business News and Their Impact on Stock Market Activity," T. Watanabe, T. Mizuno, T. Ohnishi, EPJ Data Science (2017) 6: 26.
[2] "Characterizing Social Value of Information," T. Ui, Y. Yoshizawa, Journal of Economic Theory (2015) 158: 507–535.

【Term of Project】 FY2018-2022

【Budget Allocation】 144,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.centralbank.e.u-tokyo.ac.jp/en/

【Grant-in-Aid for Scientific Research (S)】

Broad Section A

Title of Project : Towards a global standard of dignity as a philosophical concept: theoretical approaches, conceptual histories, and cross-cultural comparisons

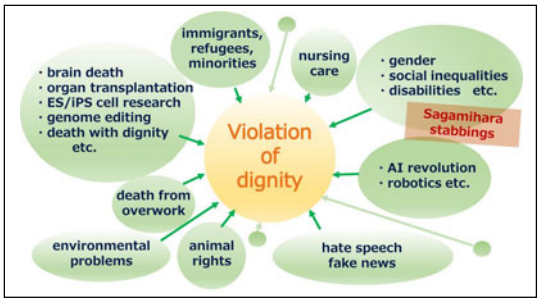
Yasushi Kato
(Hitotsubashi University, Graduate School of Social Sciences, Professor)

Research Project Number : 18H05218 Researcher Number : 90183780
Keyword : dignity, human dignity, human rights, dignity of life, autonomy, theory of value, philosophy, applied ethics

【Purpose and Background of the Research】

After WWII, the concept of dignity was adopted as one possible answer to the unprecedented catastrophe brought about by totalitarianism. Since, it has been incorporated in numerous foundational treaties and constitutional agreements, from the Charter of the United Nations and the Japanese Constitution to the EU Constitution and the Convention on the Rights of Persons with Disabilities.

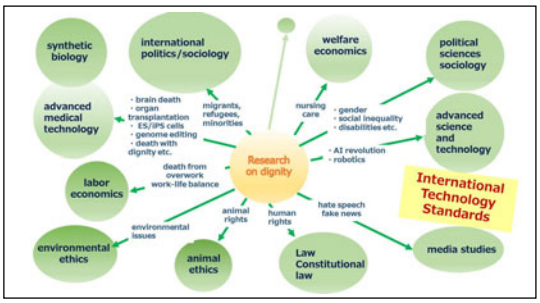
Moreover, the social acceptance of medical and other advanced technologies (e.g. ES and iPS cell research, AI etc.), as well as various pressing social issues, such as the refugee crisis and social polarization, are directly or indirectly linked to the problem of dignity (and the violation of dignity). Thus, the normative concept of dignity has become one of the keywords of the present age.



Through an exhaustive analysis, the project will aim at proposing a universally valid concept of dignity which can accommodate diversity and at the same time serve as a global standard for the advancement of democratization and social pluralization.

【Research Methods】

An international research group divided into six sub-groups will be formed to study the concept within the Western, Japanese, Chinese and Korean, Islamic, Buddhist and Indian traditions. Research will be guided by (1) a value-theoretical approach, it will (2) thoroughly reexamine the Western concept of dignity, (3) uncover the understanding of dignity within non-Western societies, and establish a comprehensive history of the concept, and ultimately (4) formulate a new understanding of dignity by contrasting, comparing and integrating Western and non-Western discourses.



【Expected Research Achievements and Scientific Significance】

By including non-Western perspectives, the project promises a paradigm shift in the research on dignity, prompting a theoretical revision of the hitherto prevailing Western anthropocentric research. At the same time, it also promises to give answers to various contemporary social problems. The research results will be published and made available to the public in the form of a collection of articles.

【Publications Relevant to the Project】

・Kato Yasushi, Kojima, Schönrich, Waldron et al. (2017) *Songen gainen no akuchuariti* (The Actuality of Dignity), special issue of the journal *Shisô* (No. 1114), Iwanami, 184pp.
・Kato Yasushi, Usami, Birnbacher, Quante et al. (2017) *Songen no dainamizumu* (The Dynamism of Dignity), Hosei University Press, 436pp.

【Term of Project】 FY2018-2022

【Budget Allocation】 130,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.soc.hit-u.ac.jp/~kato_yasushi/index.html

Title of Project : A Study on the historical Development of the Sino-Tibetan Languages and their Typological Geography

Takumi Ikeda
(Kyoto University, Institute for Research in Humanities, Professor)

Research Project Number : 18H05219 Researcher Number : 90259250
Keyword : Sino-Tibetan Languages, Old Chinese, Nomad's Type and Farmer's Type, Typological Geography

【Purpose and Background of the Research】

The aim of our research is: to investigate the geographical diversity and continuity among Sino-Tibetan languages, and search common features to trace the historical development reflected in their gradual change of structures distributed in Asia.

We also try to clarify the genealogical correlation of Sino-Tibetan languages including written languages such as Old Chinese and Tangut (Figure 1). We will conduct field research on undescribed languages, analyze the deep structure of their components, and compare with written language data. If there exists any similarity among them, we investigate if the similarity is inherited from parent languages, or a result of language contact, or of shared innovation.

Our research background is the theory of the geographical typology of Asian languages proposed by Prof. M.HASHIMOTO, we will refine and develop this theory and contribute to the descriptive and historical study on Asian languages reinforcing the critical application of a comparative method.

【Research Methods】

Our investigation plans are: (1) Field research on unrecorded languages in Sino-Tibetan. (2) Research on formation of Written Tibetan and its basic languages. (3) Grammatical analysis of the languages written in Ethnic Documents. (4) Study

Figure 1

on the Old Chinese based on excavated documents. (5) Areal transfiguration of the Chinese Dialects. And we organize semiannual workshops in spring and autumn to investigate the diversity and preserved features among S-T languages. Our topics to analyze are: Structure of noun phrase, Causative, Transitivity, Ergativity, Prosody, Directional system, Verb affixes, Evidentiality, etc. We select and order these subjects based on the accumulation of language data.

【Expected Research Achievements and Scientific Significance】

We compile new data of unrecorded languages, analyze their structure and components, unravel the mechanism of development. To start with individual analysis of S-T languages, we will find out any significant relationship among them, and reconstruct the process to make up the diversity

Figure 2

and distribution today (Figure 2). These activities lead us to understand how the geographical gradation of the language structure has been formed over S-T languages, which reflect the process of historical development.

【Publications Relevant to the Project】

IKEDA Takumi(ed.) *Grammatical Phenomena of Sino-Tibetan Languages 1 The Structure of Noun Phrases*. Institute of Research in Humanities, Kyoto University. 2016.

【Term of Project】

FY2018-2022

【Budget Allocation】

130,400 Thousand Yen

【Homepage Address and Other Contact Information】

[Under Construction]

Title of Project : The Interdisciplinary Study regarding Conserving and Utilize Methods of the Mongol Shipwrecks

Yoshifumi Ikeda
(University of the Ryukyus, Faculty of Global and Regional Studies, Professor)

Research Project Number : 18H05220 Researcher Number : 40150627
Keyword : Mongol Invasion, Mongol shipwrecks, Conserving Artifacts, trehalose

【Purpose and Background of the Research】

The members of this project have been involved in conducting studies focusing on field research methodologies, conservation of raised artifacts, and *in situ* preservation of an underwater archaeological remains at Takashima Underwater Site (at Nagasaki Prefecture, Matsumura City), the archaeological site closely associated with the Mongol Invasion of Japan. Prior projects at the site were successful in locating two Mongol vessels, and in identifying a number of locations with anomalies likely to be a sunken vessel.

To better preserve the underwater site, both of the discovered Mongol shipwrecks are being preserved *in situ*. However, there is almost no related case studies, and thus the methodology to best preserve the site underwater is still being developed. Although there is a strong voice that the hull should be raised and utilized for the public benefit, the site is covered and cannot be seen by the public.

Considering the current environment, this project aims to develop a proper method for preserving the discovered Mongol shipwrecks, raise a wreck if an important discovery were to be made, and invent techniques to conserve and to display the remains for the public to view.

【Research Methods】

This project is to conduct systematic studies on discovered shipwrecks and all excavated artifacts from Takashima Underwater Site. Specific goals are set for the project: 1) establish methodology for preserving the Mongol shipwrecks *in situ*, 2) collect information regarding the discovered hull remains and study the methodology for dissemination, 3) invent methodology for conserving artifacts raised from previous research.

【Expected Research Achievements and Scientific Significance】

Currently, Japanese Government (The Agency for Cultural Affairs) has organized a committee to discuss how Japan should manage Underwater Cultural Heritage within the country. The study of Underwater Cultural Heritage in Japan has been limited to sporadic or isolated projects, conducted by individual researchers from various fields. Including studies of particular underwater sites by researchers interested in underwater archaeology, analysis of acoustic images for identifying an underwater site by marine scientists, investigation of new methods for conserving waterlogged artifacts by conservators, and investigation by historians or archaeologists of artifacts from underwater sites and historical documents related to historical events such as the Mongol invasions.

This project focused on the study of the Mongol Shipwrecks - establishing methodologies for preserving the site *in situ* and the conservation techniques of large remains of waterlogged wood, and the creation of various contents for dissemination for the public - will be the leading examples of the field. The successful publication of this project will illustrate to the world how underwater cultural heritage is being managed and research in Japan.

【Publications Relevant to the Project】

Ed.Makoto Sato “History of the Underwater site” Yamakawa Shuppansha Ltd 2018

【Term of Project】

FY2018-2020

【Budget Allocation】

82,600 Thousand Yen

【Homepage Address and Other Contact Information】

In progress

Title of Project : Development of Integrated Knowledge through Establishment of an Interactive Research Scheme based on the Open-Data of Research Resources for Wooden Tablets and Related Topics

Hajime Baba
(National Institutes for Cultural Heritage, Nara National Research Institute for Cultural Properties, Department of Imperial Palace Sites Investigations, History Section, Chief)

Research Project Number : 18H05221 Researcher Number : 70332195
Keyword : Wooden Tablets, Open Data, Writing System, Japanese History

【Purpose and Background of the Research】

Wooden tablets are important primary historical sources in various researches. That said, they are extremely fragile and difficult to display thus need to be made more available for detailed research. As the national center of research on wooden tablets, Nara National Research Institute for Cultural Properties (Nara Institute) has developed and published online a set of databases.

However, research concerning wooden tablets has greatly evolved. Databases developed individually by separate institutes no longer apply to current research needs. A new approach is needed.

The goal of the current research is to prompt a paradigm shift of the accessibility of research resources from "unilateral provision" to "bilateral sharing" and create an environment of knowledge sharing, through which to pioneer research on wooden tablets and written historical sources (particularly on historical characters) in East Asia and the rest of the world.

【Research Methods】

The current research hopes to achieve its goals through steps A)–C) below:

A) Increasing the "quantity" of resources
a. Making protocols of open-data on historical characters.
b. Imaging the Nara Institute's research resources in a format that complies with IIIF
c. through b, Establish the context for coordination
B) Achieving "greater variety" of resources
a. Developing tools encouraging participation
b. Archiving empirical knowledge
c. Enhancing annotation on historical scripts
C) Developing new research
a. Studies involving techniques of big data
b. Spurring, furthering, and publicizing interdisciplinary and international research

【Expected Research Achievements and Scientific Significance】

Nara Institute owns the largest collection of data on wooden tablets. Formatting those in accordance with IIIF will facilitate inter-institutional and international coordination and collaboration.

Empirical knowledge will be directly archived by utilizing information technology in steps from unearthing to archiving, and compiled "knowledge" will be disseminated via instant messaging.

Analysis of recently archived empirical knowledge and observations should lead to diverse results.

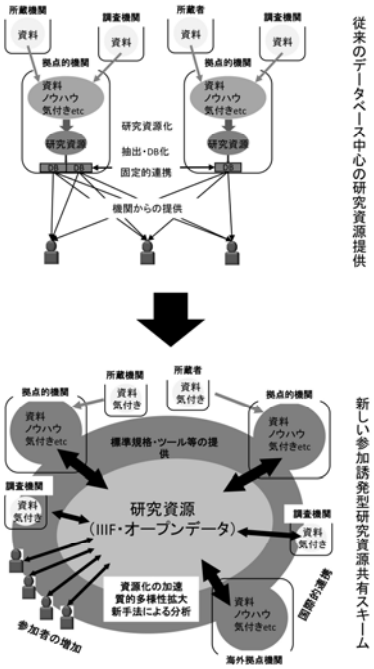


fig1 Our new scheme

The current research seeks mainly to identify specific aspects of ways in which characters were written when written culture emerged in Japan.

【Publications Relevant to the Project】

Hajime, BABA "The Study for Japanese Ancient Wooden Tablets "Yoshikawakobunkan, 2018
Supervised by Harumichi ISHIZUKA, Edited by Tomokazu TAKADA, Hajime BABA, Shoichi YOKOYAMA, "The Study for Kanji character font history" Bensei-shuppan, 2016

【Term of Project】 FY2018-2022

【Budget Allocation】 96,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://mokkanko.nabunken.go.jp/en/

【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project : Chemical Composition of Disk Forming Regions of Solar-type Protostars and its Evolution to Planetary Systems

Satoshi Yamamoto
(The University of Tokyo, Graduate School of Science, Professor)

Research Project Number : 18H05222 Researcher Number : 80182624
Keyword : Radio Astronomy

【Purpose and Background of the Research】

A detailed understanding of the evolution of matter during star and planet formation is of fundamental importance in elucidating the origin of the Solar System. In this project, we will explore the chemical diversity of protostellar sources and its evolution to planetary systems through high-resolution radio observations with ALMA. The main goals are (1) to reveal an entire view of the chemical diversity by observations of about 20 protostellar sources, (2) to resolve the transition zone from the envelope to the disk for a few representative sources at the highest angular resolution of ALMA, and (3) to investigate the origin of the chemical diversity in a statistical way by observing many protostellar sources in a single molecular cloud complex. For the 5 year term of this project, we are going to reveal basic laws of the chemical evolution of protostellar sources for an understanding of our origin in the universe.

【Research Methods】

To achieve the above goals, we are going to conduct extensive observations of molecular lines with a full use of ALMA.

(1) Evolution of Chemical Diversity: So far, the observational data with a resolution of a few 10 au have been delivered for a few sources. We are going to analyze these data, and to prepare proposals for further ALMA observations. For 5 years, we will eventually explore about 20 protostellar sources, and reveal basic laws of the chemical evolution. In addition, we will study chemical processes in disk forming regions by chemical network calculations.

(2) Chemical and Physical Processes in Disk Forming Regions: Complex physical and chemical processes, including a launch of outflows, seem to occur around the centrifugal barrier of the infalling-rotating envelope gas. We will reveal its detailed structure at the highest angular resolution.

(3) Origin of Chemical Diversity: Observations of a number of protostellar sources in the Orion and Perseus clouds have already been conducted with ALMA. Chemical diversity and its origin will be studied in a statistical way by using the CH_3OH and CCH lines. We will propose ALMA observations of other molecular complexes for comparison.

In parallel to the observational studies, we are going to conduct laboratory measurements of rest frequencies of molecular lines including those of isotopic species with an accuracy better than 0.01 MHz by using a new submillimeter spectrometer at RIKEN. The obtained rest frequencies will widely be used for the above ALMA analysis.

【Expected Research Achievements and Scientific Significance】

This is the first attempt of systematic studies of chemical evolution in disk forming regions by a full use of ALMA. The result will provide us with crucial information on how chemical diversity of the envelope is inherited into planetary systems. It will significantly contribute to our understanding of the initial chemical environment of the Solar System in combination with results expected from exploration of small Solar System bodies

【Publications Relevant to the Project】

・Sakai et al., 2014, Nature, 507, 79-80.
・Oya et al. 2016, Astrophys. J. 824, 88 (19 pp).
・Sakai et al. 2017, Mon. Not. R. Astr. Soc. 467, L76-L80.

【Term of Project】 FY2018-2022

【Budget Allocation】 144,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.resceu.s.u-tokyo.ac.jp/~submm/

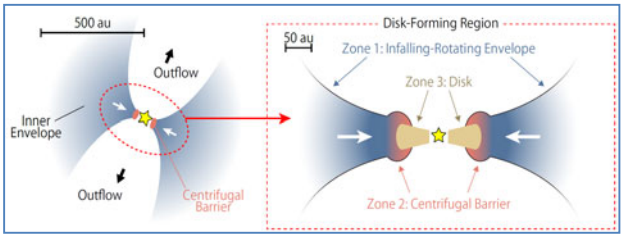


Figure 1: Schematic illustration of a disk forming region to be studied with this project.

Title of Project : Identifying the origin of the type-Ia supernova by observations just after the explosion

Mamoru Doi
(The University of Tokyo, Graduate School of Science, Professor)

Research Project Number : 18H05223 Researcher Number : 00242090
Keyword : Type Ia supernova, Progenitor, Explosion Mechanism, Standard Candle, Dark Energy

【Purpose and Background of the Research】

The type Ia supernova (SNIa) provides important heavy elements of the universe such as Iron, and also a good standard candle for Cosmology being used to find acceleration of the expansion of the Universe. But the progenitor of SNIa is not identified yet. Recently we found a SNIa whose explosion was triggered by detonation of a thin Helium layer by observations about half day after its ignition, which shows that a key to unveil the progenitor of SNIa is early phase observations just after the explosion.

There are other studies which imply that SNeIa may have different explosion mechanisms and may be originated from different progenitor systems. Statistical studies of SNeIa in very early phase are promising to classify the ignition mechanisms as well as progenitors of SNIa.

In this study, we aim to obtain high quality observational data of SNeIa with newly developed instruments, and to compare observational results with theoretical models to understand diversity of color and luminosity of SNeIa and to unveil the origin of SNeIa. Simultaneously we make template spectra of SNeIa in Near Infrared wavelengths (NIR) in order to make the SNIa as a standard candle in NIR.

【Research Methods】

We complete the CMOS wide-field camera, Tomo-e, at the prime focus of the 1-m Kiso Schmidt telescope, operated by the University of Tokyo,

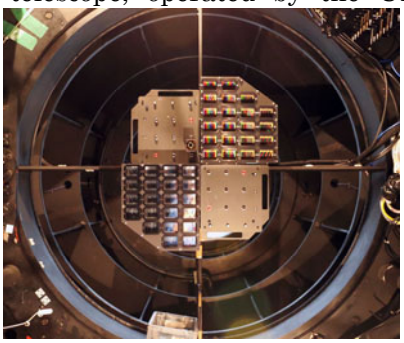


Figure 1. A wide-filed CMOS camera, Tomo-e, being built at the prime focus of Kiso Schmidt. So far, 21 sensors are installed, and more sensors are being installed.

and will use Tomo-e to find nearby SNeIa from their very early phase. Tomo-e will have 84 CMOS sensors and will be the most powerful instrument to find bright supernovae. With repeated 2-hour cadence imaging, Tomo-e can find all SNeIa in the northern sky (Dec. > -20 deg.) brighter than V=19 mag except for very crowded regions. Then we will carry out follow-up observations with a newly developed multi-band camera and an upgraded IFU spectrograph attached to the Seimei 3.8-m telescope, Kyoto University. We will compare multi-band photometry and spectra of more than 30 SNeIa with theoretical models, and will carry out statistical studies. We also make template spectra of about 30 SNeIa in NIR with a few day cadence with NICE, an Echelle spectrograph on the 6.5-m TAO telescope, operated at the world highest site, Atacama, Chile by Univ. of Tokyo.

【Expected Research Achievements and Scientific Significance】

Thus we carry out statistical photometric and spectroscopic studies of more than 30 SNeIa, and understand the progenitor and the explosion mechanism of SNIa. At the same time, a set of NIR spectroscopic template of SNeIa, which enables SNIa to be a standard candle in NIR. Overall, this study will be an important step to understand the origin of SNIa and, in the long run, the origin of the acceleration of the Universe, i.e. Dark Energy.

【Publications Relevant to the Project】

・"A hybrid type Ia supernova with an early flash triggered by helium-shell detonation", Jiang, J., Doi, M., Maeda, K.et al., Nature, 550, pp.80-83. (2017)
・"Photometric properties of intermediate redshift Type Ia supernovae observed by the Sloan Digital Sky Survey-II Supernova Survey", Takanashi, N., Doi, M. et al., MNRAS, 465, p.1274-1288 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 147,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ioa.s.u-tokyo.ac.jp/~doi/doi's_project.htm

【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project : Material Science of Hydrogen in the deep earth and planets

Hiroyuki Kagi
(The University of Tokyo, Graduate School of Science, Professor)

Research Project Number : 18H05224 Researcher Number : 70233666
Keyword : hydrogen, the earth's interior, planetary interior, neutron diffraction

【Purpose and Background of the Research】

Hydrogen is the most abundant element in the solar system and the simplest element containing only one electron. However, the chemical property of hydrogen has a wide variety caused by its multiple bonding nature. From these reasons, hydrogen can constrain the properties and structure of materials in the deep earth and planets. In this research project, we are going to solve fundamental questions on structures, properties and behaviors of hydrogen-containing minerals in the deep earth and planets from versatile experiments at high pressure and high temperature or low temperature. The purpose of the project is to clarify the thermodynamic stability, crystal structure, chemical composition of hydrogen-beading materials in the deep earth and planets. The targets of our project cover very wide range of materials as illustrated in Figure 1.

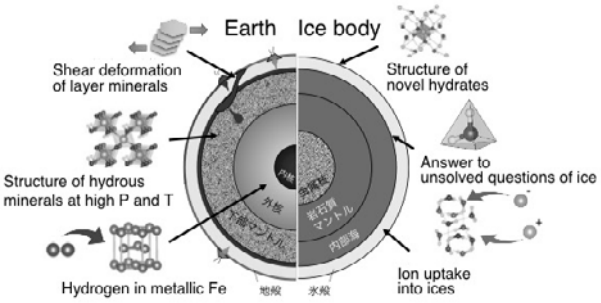


Figure 1 Targets of our research.

【Research Methods】

Main experimental method in this research project is neutron diffraction measurements at high pressure at the PLANET beamline (BL-11), MLF, J-PARC (see Figure 2). The PLANET beamline was constructed by a research consortium led by members in this research project. Crystal structures of the materials in the deep earth and planets will be solved from X-ray diffraction measurements at PF, KEK and local structure surrounding hydrogen atoms will be obtained from neutron diffraction measurements at MLF, J-PARC. In this research, laboratory-based instruments will be also installed to support the measurements at

Figure 2 BL-11 at MLF, J-PARC.

J-PARC and KEK, because beamtime distributed to us is very limited. In this project, we will solve the phase relationship of salt-water systems at high pressure and low temperature to clarify the internal structure of icy bodies. Moreover, the occupancy and local structure of hydrogen atoms in metallic iron will be clarified at high pressure and high temperature conditions.

【Expected Research Achievements and Scientific Significance】

Structure and chemical compositions of the earth's core and icy planets will be clarified from this research project.

【Publications Relevant to the Project】

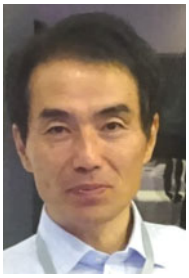
・Hattori et al. (2015) Design and performance of high-pressure beamline PLANET launched at pulsed neutron source at J-PARC. NIM A, 780, 55.
・Iizuka-Oku et al. (2017) Hydrogenation of iron in the early stage of Earth's evolution. Nature Comm., 8, 14096, DOI: 10.1038/ncomms14096.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.eqchem.s.u-tokyo.ac.jp



Title of Project : Creation of a new discipline, quantum glass, for electronic systems and its development to material science

Kazushi Kanoda
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05225 Researcher Number : 20194946
Keyword : molecular solid, strongly correlated electron system, liquid and glass, soft matter

【Purpose and Background of the Research】

The physics of strongly interacting electrons has advanced into a fertile field owing to their diverse and emergent phenomena with microscopic orders of charges and spins. Recent studies, however, suggest that interaction may cause heterogeneous self-organizations of electrons on scales far larger than molecular size and their extremely slow dynamics – the very characteristics of soft matters.
In the present study, we investigate electronic systems exhibiting spatiotemporal variation on anomalously large scales in terms of soft matters, aiming to establish a new notion, "quantum glass of electrons", that possesses charge and spin of quantum nature, not available in conventional glasses. This research project tries to create a new interdisciplinary filed linking two sciences of strongly correlated electrons and soft matters, so far developed separately (Fig.1).

【Research Methods】

The project is conducted in close collaboration between three groups performing physical property measurements, material synthesis and theoretical studies, seeking quantum glass matters, their control and a new notion of electronic rheology.
The measurement group studies the spatiotemporal variation of electronic states by NMR, electron transport and permittivity measurements and scanning microspectroscopy, and further tackles non-equilibrium phase control (Fg.2). The synthesis group designs and synthesizes materials for

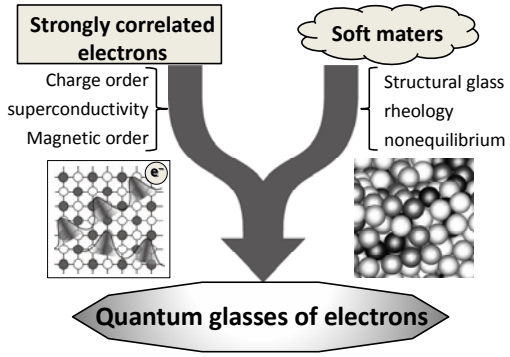


Figure 1

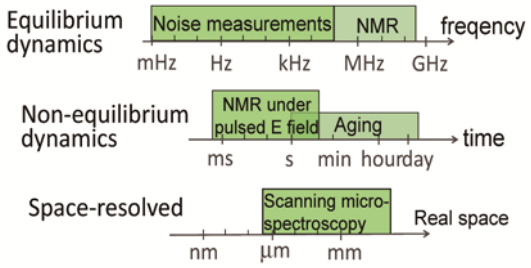


Figure 2

electronic glasses by the chemical modification of molecules and the introduction of proton electron interactions. The theory group elaborates effective models for electronic glasses to elucidate the origin of the slow dynamics.

【Expected Research Achievements and Scientific Significance】

We aim to develop a new research area, quantum glass, which originates from interacting electrons. This project tackles an essential issue of how soft matters so-far studied in the classical framework meet electrons of quantum nature. It is expected that soft matters of quantum nature come out and novel phase control exploiting slow dynamics and non-equilibrium nature is developed.

【Publications Relevant to the Project】

・T. Sato, K. Miyagawa and K. Kanoda, "Electronic crystal growth", Science **357**, 1378-1381 (2017).
・T. Itou, E. Watanabe, S. Maegawa, A. Tajima, N. Tajima, K. Kubo, R. Kato and K. Kanoda, "Slow dynamics of electrons at a metal–Mott insulator boundary in an organic system with disorder", Sci. Adv. **3**, e1601594-1-6 (2017).

【Term of Project】 FY2018-2012

【Budget Allocation】 151,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://park.itc.u-tokyo.ac.jp/kanoda_lab/

Title of Project : Search for new symmetry violation in leptons

Toru Iijima
(Nagoya University, Center for Experimental Studies, Professor)

Research Project Number : 18H05226 Researcher Number : 80270396
Keyword : Experimental particle physics, lepton, accelerator, particle detectors

【Purpose and Background of the Research】

Although the Standard Model (SM) of particle physics has been established with confirmation of the Kobayashi-Maskawa theory to explain the CP violation and also discovery of the Higgs boson to explain the origin of the mass, there are still mysteries of the Universe; How the anti-matter disappeared? What is the dark matter? What is the dark energy? To solve such mysteries, discovery of New Physics (NP) beyond the SM would be the first step. Here, violation of symmetry or conservation law play important role, and there have been many findings in the quark and neutrino sectors in the past.

In fact, we have found that the B meson prefers decaying to the final state with τ ($D\tau\nu$) rather than those with e ($De\nu$) or μ ($D\mu\nu$). There are also reported deviations from the SM in rare B meson decays ($B\to K^{(*)}e^+e^-$, $B\to K^{(*)}\mu^+\mu^-$) and in the anomalous magnetic moment of the muon, $(g-2)_\mu$.

In this research, we will clarify the existence of new symmetry violations in the charged lepton sector, in data taken by SuperKEKB/Belle II experiment and the J-PARC g-2/EDM experiment (E34), and discover New Physics.

【Research Methods】

In the proposed research, we search for lepton universality violations in the tauonic B decays and rare B meson decays, and lepton flavor violation in τ decays. To achieve this goal as early as possible, we will perform R&D to improve the detector performance, and develop computing architecture to process big data samples. Moreover, we will improve the SM prediction of the $(g-2)_\mu$, by precision measurement of the e+e- cross section to estimate the contribution of the hadronic loop effect. We also plan to improve the performance of E34 by transferring expertise developed for the Belle II experiment.

【Expected Research Achievements and Scientific Significance】

We plan to accumulate data about 30 times more than presently available. Together with the detector improvement, we will clarify the lepton universality and lepton flavor violation. In parallel, we try to start the E34 experiment. If deviations are found clearly in some of these measurements, we will be able to claim NP and also elucidate the NP model from correlations.

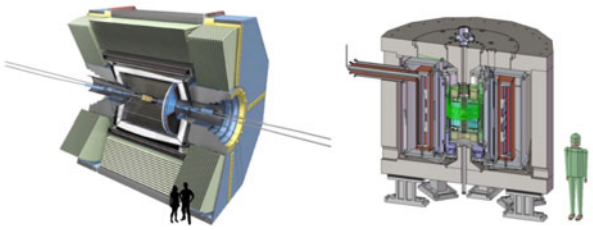


Figure 1 Belle II experimrnt (left) and J-PARC E34 experiment (right)

【Publications Relevant to the Project】

・"Measurement of the τ lepton polarization and R(D*) in the decay $B\to D^*\tau\nu$", S. Hirose, T. Iijima, K. Hayasaka et al., Phys. Rev. Lett. 118, 211801 (2017).
・"Measurement of the branching fraction of $B0\to D^*\tau\nu$ relative to $B0\to D^*l\nu$ decays with a semileptonic tagging method", Y. Sato, T. Iijima, K. Hayasaka et al., Phys. Rev. D94, 072007 (2016).

【Term of Project】

FY2018-2022

【Budget Allocation】

147,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://wru.hepl.phys.nagoya-u.ac.jp/

Title of Project : Rotational Symmetry Breaking in Strongly Correlated Quantum Matters

Yuji Matsuda
(Kyoto University, Graduate School of Science, Professor)

Research Project Number : 18H05227 Researcher Number : 50199816
Keyword : Strongly Correlated Electrons, Quantum spin systems, Rotational Symmetry Breaking

【Purpose and Background of the Research】

Recently, nematic transition, in which electronic structure spontaneously break the underlying lattice symmetry has aroused great interest in strongly correlated systems, including cuprates, iron-pnictides, heavy fermion systems. The clarification of the origin of the nematic transition is very important because it is closely related to the long-standing central issues of condensed matter physics, such as pseudogap formation, unconventional superconductivity, hidden order and quantum criticality. Moreover, quantum spin liquid state in insulating systems, in which the long range magnetic order is destroyed by quantum fluctuations, has attracted much attention recently as a novel quantum phase. Ground states of these quantum spin liquid states, however, have been poorly explored so far. In particular, what kind of symmetry breaking occurs in these quantum spin liquid state is an unresolved issue. In this project, to clarify the rotational symmetry breaking in these novel quantum systems, we develop the ultrahigh sensitive torque magnetometry, which makes us possible to detect the magnetic anisotropy in unprecedented precision.

【Research Methods】

In a wide temperature range from 50 mK to 400 K, we develop the ultrahigh sensitive torque magnetometry, For the precise measurements of the in-plane magnetic torque, we use a system consisting of a two-dimensional vector magnet and

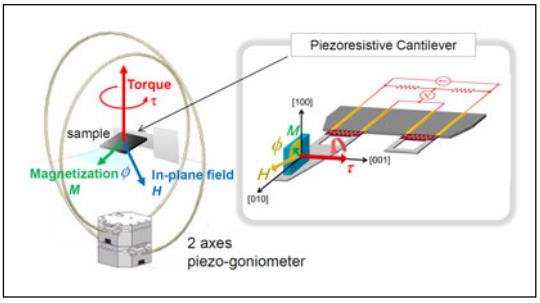


Figure 1

a mechanical rotator (see Fig.1), which enables us to rotate the magnetic field **H** within the *ab* plane. Computer controlling the vector field and mechanical rotator systems, we eliminate the misalignment and rotate **H** within the *ab* plane with the accuracy better than 0.1 degree.

【Expected Research Achievements and Scientific Significance】

It has been widely recognized that strongly correlated quantum many body systems exhibit various types of symmetry breakings. In this project, we clarify the rotational symmetry breaking in strongly correlated superconductors, including heavy fermion compounds, high-Tc cuprates and iron-pnictides, correlated electron systems with strong spin-orbit interactions, including irridates, and quantum spin liquids. These studies are expected to provide a key to understanding important aspects of long-standing unresolved issue in condensed matter physics.

【Publications Relevant to the Project】

・Y. Sato, *et al.* "Thermodynamic evidence for a nematic phase transition at the onset of the pseudogap in $YBa_2Cu_3O_y$" Nature Phys. 13, 1074–1078 (2017).
・S. Kasahara *et al.* "Electronic nematicity above the structural and superconducting transition in $BaFe_2(As_{1-x}P_x)_2$" Nature 486, 382-385 (2012).
・R.Okazaki *et al.* "Rotational Symmetry Breaking in the Hidden-Order Phase of URu_2Si_2" Science 331, 439-442 (2011).

【Term of Project】 FY2018-2022

【Budget Allocation】 198,250 Thousand Yen

【Homepage Address and Other Contact Information】

http://kotai2.scphys.kyoto-u.ac.jp/index.php
matsuda@scphys.kyoto-u.ac.jp

Title of Project : Exploration of new quantum condensed phase by exploiting orbital and spin degrees of freedom of ultracold atomic gases in an optical lattice

Yoshiro Takahashi
(Kyoto University, Graduate School of Science, Professor)

Research Project Number : 18H05228 Researcher Number : 40226907
Keyword : quantum electronics, cold atom, quantum simulation, optical lattice

【Purpose and Background of the Research】

The researches using the quantum gases have been quite active. Among them, especially interesting is quantum simulation of quantum many-body system described by so called Hubbard model using cold atoms in an optical lattice which is the periodic potentials for atoms (See Fig. 1). The cold atoms in an optical lattice are well described by the Hubbard model which consists of hopping term and on-site interaction term. This Hubbard model is an important one which describes strongly correlated electron system such as itinerant magnetism and unconventional superconductivity.

Under this background, we aim at the significant advancement of research on physical properties of quantum condensed phases by exploiting novel orbital degrees of freedom which can be realized by non-standard optical lattice, and novel spin degrees of freedom of high spin symmetry offered by two-electron atoms.

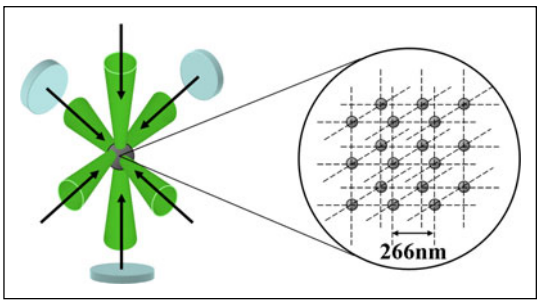


Figure 1 Optical lattice

We mainly exploit ytterbium (Yb) atomic system which possess SU(N=6) symmetry, and carry out unique experiments by constructing a Lieb optical lattice which possess flat-band and two-orbital systems of localized and itinerant characters. In addition, we develop a high-resolution imaging and controlling technique to realize a unique quantum simulator.

【Research Methods】

We plan to perform the following four research topics:

"study of quantum magnetism and superfluidity realized by flat band of optical Lieb lattice", "study of two-orbital system with localized and itinerant characters", "study of SU(N) quantum magnetism", and "New possibilities on unique orbital degrees of freedom".

【Expected Research Achievements and Scientific Significance】

Our research which focuses novel multi-orbital and highly-symmetric spin degrees of freedom is quite unique, only possible by two-electron atomic system which we have been developing. We expect significant advancement of quantum simulation research as well as condensed matter theory and computational science, which will give us an important guideline of material synthesis.

【Publications Relevant to the Project】

・T Tomita, S Nakajima, I Danshita, Y Takasu, and Y Takahashi, "Observation of the Mott insulator to superfluid crossover of a driven-dissipative Bose-Hubbard system", **Sci. Advances, 3**, 2017, e1701513 (1-8).

・S. Taie, H. Ozawa, T. Ichinose, T. Nishio, S. Nakajima, and Y. Takahashi, "Coherent driving and freezing of bosonic matter wave in an optical Lieb lattice", **Sci. Advances, 1**, 2015, e1500854(1-6).

【Term of Project】 FY2018-2022

【Budget Allocation】 144,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://yagura.scphys.kyoto-u.ac.jp/

Title of Project : Neutron Structural Biology for New Generation

Masaaki Sugiyama
(Kyoto University, Institute for Integrated Radiation and Nuclear Science, Professor)

Research Project Number : 18H05229 Researcher Number : 10253395
Keyword : protein dynamics, neutron scattering

【Purpose and Background of the Research】

In these days, not only structure but also dynamics has been highlighted to understand functions of biomacromolecules.

Figure 1 shows the relation between structure and dynamics, taking multi-domain protein (MurD) as an example. A hierarchic structure of the protein is shown in Fig.1(u): "amino acid reside" is a basic unit (10^{-11}-10^{-10} m), "domain" is a unit of 3D structure (10^{-10}-10^{-9} m), "whole structure" is constituted with the domains (10^{-9}-10^{-8} m), "complex / aggregates" is connected by other protein(s) and/or molecules(s) (>10^{-8} m). Next, based on MD simulation, the time range of dynamics of each structure is displayed on a spatio-temporal map (Fig.1(d)): Zones 1-4 correspond to the dynamics of amino acid reside (10^{-15}-10^{-12} s), domain (10^{-12}-10^{-9} s), whole structure (10^{-9}-10^{-6} s) and complex / aggregates (>10^{-6} s), respectively. Experimentally, there are several methods to observe the dynamics for Zones 1 and 4 but and there are not for Zones 2 and 3, namely an experimental "missing zone".

Neutron scatterings have possibilities to cover the missing zone in principle. However, the beam intensity was not enough to observe dynamics of protein in solution. Recently, the situation is going to change: J-PARC has supplied the brilliant beam and their spectrometers are having ability to observe the dynamics.

Purposes of this project are establishment of the methods to measure the protein dynamics in the missing zone and development of the analyzing method coupled with MD simulation by making full use of the latest neutron spectrometers.

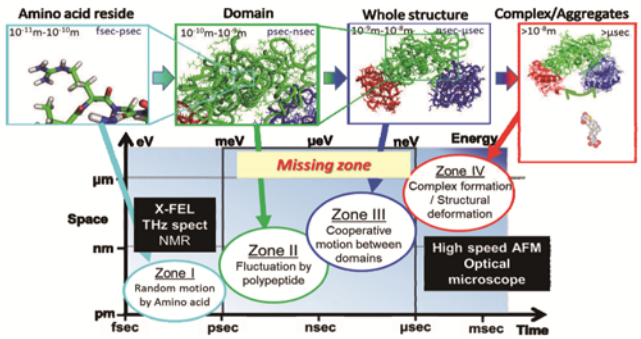


Figure 1. Relation between structure and dynamics in a multi-domain protein. (up) Hierarchic structure. (down) Dynamics of each structure on spatio-temporal map.

【Research Methods】

This project proceeds development and empirical studies. Three techniques, high level protein deuteration, measurement for protein dynamics with QENS, NSE and SANS, and data analysis coupled with MD simulation, will be developed. Then, by integrating the developed techniques, the protocol will be established to reveal protein dynamics in the missing zone. In the empirical study, the first targets are two proteins with high biological significances: MurD is a typical multi-domain protein and Hef is an intrinsically disordered protein. Then, the targets expand more.

【Expected Research Achievements and Scientific Significance】

This project will not only develop methods to cover the missing zone but also reveal dynamics of proteins with high biological significances. With these results, it is expected to reveal a transfer mechanism from random motion of amino-acid resides to cooperative motion between domains.

The developed methods will be open for all researches who are interesting of protein dynamics. Then, it is also expected that Japanese facilities such as J-PARC becomes center of neutrons biology. In addition, the most of project members are young and up-coming researches. Therefore, they will play a central role in this field in the next 10 years.

【Publications Relevant to the Project】

・P. Bernadó, M. Sugiyama, etal., BBA General Subjects, 1862 (2018) 253-274.
・R. Inoue, M. Sugiyama, etal., Sci. Rep., **6** (2016) 29208.

【Term of Project】 FY2018-2022

【Budget Allocation】 151,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.rri.kyoto-u.ac.jp/NSBNG

Title of Project : Search for the neutron electric dipole moment and the time reversal violation

Kichiji Hatanaka
(Osaka University, Research Center for Nuclear Physics, Specially Appointed Professor)

Research Project Number : 18H05230 Researcher Number : 50144530
Keyword : Particle physics, Nuclear physics, Symmetry, Ultracold neutron, Electric dipole moment

【Purpose and Background of the Research】

The current standard cosmology describes our Universe and its evolution starting from the Big Bang and following Inflation. The early Universe was in thermal equilibrium of particle-antiparticle annihilation. The Universe was cooled down by its expansion and the small amount of matter remained. Combined charge and parity (CP) reversal symmetry violation can be related to the matter-antimatter asymmetry. The standard model (SM) of particle physics describes the CP violation in the quark sector by CKM matrix. CP violation in neutrino sector was also observed by the T2K experiments. However, they are not enough to explain the matter-antimatter asymmetry in the present Universe. A new physics beyond SM is necessary.

A permanent electric dipole moment (EDM) of a fundamental particle violates time reversal (T) symmetry and therefore also CP symmetry assuming CPT conservation. The EDM is a good probe for searching a new physics beyond SM.

【Research Methods】

Ultracold neutrons (UCN) are neutrons of which kinetic energy is remarkably small (< 300 neV). Therefore, they can be stored in a material vessel. Neutron EDM (nEDM) is measured by observing the spin precession frequency of UCN in both the magnetic and electric fields. A high density UCN source is constructed and developed at TRIUMF (see Fig. 1). The UCN source enable us to measure the nEDM in the sensitivity of 10^{-27} ecm.

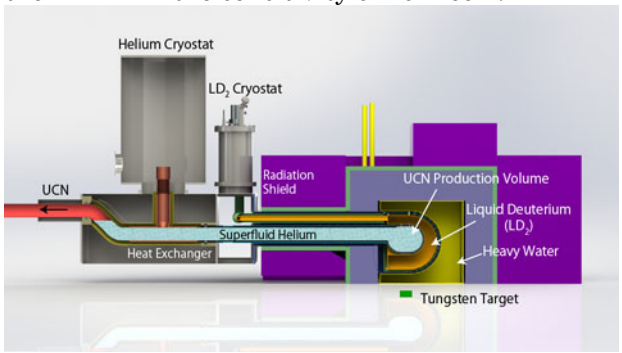


Figure 1 Schematic layout of the UCN source

Neutrons produced upon spallation reaction on the tantalum-clad tungsten target are moderated by room temperature heavy water. A large flux of cold neutrons around 1 meV is created by further moderation in 20 K liquid deuterium. Conversion to UCN happens in superfluid liquid ^{4}He around 1K where the cold neutrons are downscattered creating phonons and rotons in the liquid.

UCN are transported from the source to a storage vessel preserving their polarization. nEDM is measured by precisely observing the frequency of UCN spin precession in stable magnetic and electric fields using Ramsey resonance method. Systematic errors mainly arise from a geometric phase effect caused by gradients and fluctuations of the magnetic field. We will achieve uniform (< 1 nT/m) and stable (< 1 pT/100 s) magnetic fields by applying active compensation coils and a 4-layer shielded room.

【Expected Research Achievements and Scientific Significance】

SM predicts a nEDM at the level of 10^{-32} to 10^{-31} ecm. On the other hand, a new physics such as SUSY model predicts nEDM around 10^{-28} to 10^{-26} ecm. The current best experimental upper limit is 3×10^{-26} ecm measured with UCN at Institute Laue Langevin (ILL). We will search nEDM in the level predicted by new physics.

【Publications Relevant to the Project】

・R. Golub and J. Pendlebury, Phys. Lett. A 62, 337 (1977)
・J. M. Pendlebury et al., Phys. Rev. D. 92, 092003 (2015)
・Y. Masuda et. al, Phys. Rev. Lett. 108, 134801 (2012)

【Term of Project】

FY2018-2022

【Budget Allocation】

152,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://fnp.kek.jp

Title of Project : New Initiative on Search for Charged Lepton Flavor Violation with Highly Intense Muon Source

Yoshitaka Kuno
(Osaka University, Graduate School of Science, Professor)

Research Project Number : 18H05231 Researcher Number : 30170020
Keyword : Elementary Particle

【Purpose and Background of the Research】

One of the most important subjects in elementary particle physics is to search for new physics phenomena beyond the Standard Model (SM). Charged lepton flavor violation (CLFV) is known not to occur in the framework of the SM, whereas it is expected to occur in the new physics models. Therefore, CLFV is considered to be one of the best to search for new physics. One of the most important CLFV processes is muon to electron conversion (μ-e conversion) in a muonic atom. We are preparing an experiment to search for it with a factor of about 100 improvement over the previous search. This experiment is called the COMET (J-PARC E21) Phase-I experiment. In particular, in this project, we will improve its experimental sensitivity by another 8 times over the original proposal of COMET Phase-I.

【Research Methods】

The present research method is to construct the COMET Phase-I detector to carry out our research for μ-e conversion. The detector is a cylindrical drift chamber (CDC) where a muon stopping target made of aluminium is placed at the center of the

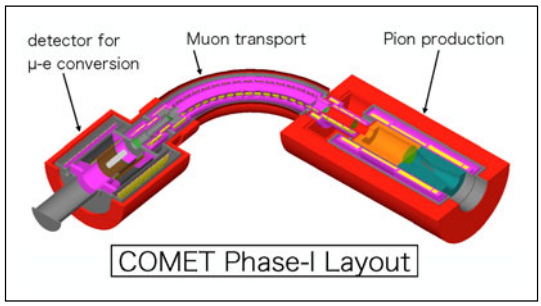


Figure 1

CDC. In particular, in this project, we intend to make three modifications of improvement. They are as follows; (1) We will install another solenoid magnet (named the Bridge Solenoid) between the solenoids of the muon transport section (3T) and the detector solenoid (1T). It would be useful to increase a total number of muons stopped and to reduce background hits. (2) We will replace all the silicon-based photon sensors for the CDC trigger counters, by fine-mesh photomultipliers, and will place additional radiation shielding for them (3) We will make special selection of the parts and FPGA used in the frontend electronics of the CDC to make them stronger against radiation.

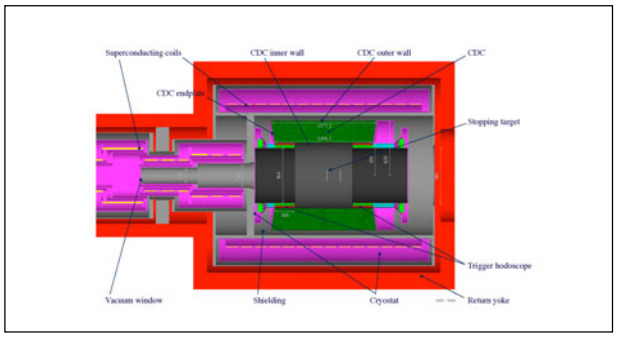


Figure 2 CDC layout

【Expected Research Achievements and Scientific Significance】

The COMET Phase-I with the proposed modifications, will intend at the 800 times improvement to aim at the discovery. If it is found, it would make a big paradigm change in the elementary particle physics.

【Publications Relevant to the Project】

・ Y. Kuno, "A Search for Muon-to-electron Conversion at J-PARC: The COMET Experiment", PTEP 2013 (2013) 022C01, DOI : 10.1093/ptep/pts089
・ Y. Kuno and Y. Okada, "Muon Decay and Physics beyond the Standard Model", Rev. Mod. Phys. 73 (2001) 151-202, DOI : 10.1103/Rev/ModPhys.73.151

【Term of Project】 FY2018-2022

【Budget Allocation】 148,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www-kuno.phys.sci.osaka-u.ac.jp/mlfv/

Title of Project : Experimental study on syn-deformational reaction processes at high pressures: Implications for slab weakening and deep earthquakes

Tomoaki Kubo
(Kyushu University, Faculty of Science, Professor)

Research Project Number : 18H05232 Researcher Number : 40312540
Keyword : Earth's deep material, transformation, deformation, high pressure, synchrotron radiation

【Purpose and Background of the Research】

Large deformation of subducting slabs and deep earthquakes in the mantle transition zone (Fig. 1) are still unresolved issues in mantle dynamics. Previous studies have suggested that the grain-size reduction due to non-equilibrium transformations leads to weakening and/or shear instability, which may be responsible for the slab stagnation and deep earthquakes. However, there have been few direct experimental evidences on the coupling process. We conduct synchrotron radiation and FIB-TEM studies combined with seismological investigation to constrain the role of the olivine transformations on the slab weakening and deep earthquakes.

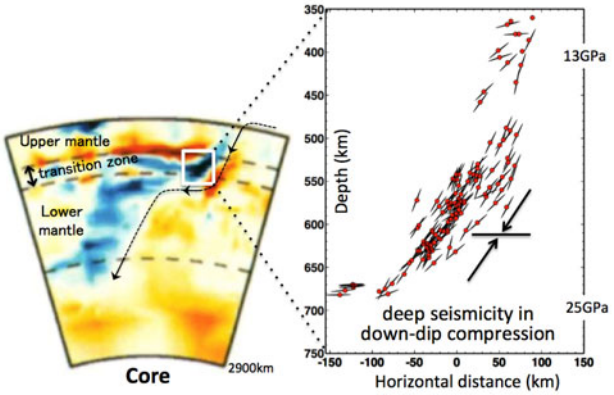


Fig. 1 Large deformation of subducting slab and distributions of deep earthquakes in mantle transition zone.

【Research Methods】

We conduct high-pressure deformation experiment at mantle transition zone conditions by using D-DIA and D-111 type apparatus. We focus on the interaction between deformation and the olivine-spinel and the post-spinel transformations. Simultaneous in-situ observations of reaction kinetics, creep behaviors, and acoustic emission (AE) activities are possible with the use of synchrotron X-ray and AE measurement system (Fig. 2). Reaction and deformation microstructures in recovered samples are examined by FIB-TEM analysis. The result is compared with that observed in shocked meteorites. We also conduct seismological studies on the field of metastable olivine, topography of the 660 km discontinuity, multiple discontinuities, and their relationships with distributions of deep earthquakes.

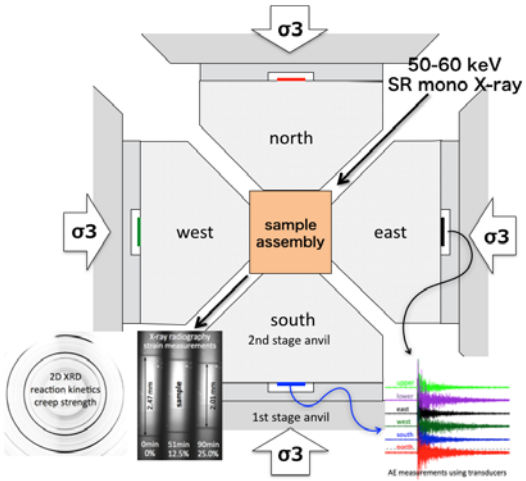


Fig. 2 D-DIA type high-pressure deformation apparatus and in-situ observations of transformation kinetics, creep behaviors, and AE activities

【Expected Research Achievements and Scientific Significance】

By using these techniques, we investigate the details of reaction-induced weakening, shear localization, and shear instability under mantle transition zone conditions. Interdisciplinary research combining high-pressure mineral physics with meteoritics and seismology is crucial to understand the slab behaviors in mantle transition zone.

【Publications Relevant to the Project】

Doi N., Kato T., Kubo T., Noda M., Shiraishi R., Suzuki A., Ohtani E., Kikegawa T., Creep behavior during the eutectoid transformation of albite: Implications for the slab deformation in the lower mantle. Earth Planet. Sci. Lett., 388, 92-97, 2014

【Term of Project】 FY2018-2022

【Budget Allocation】 108,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://mineral2.geo.kyushu-u.ac.jp/saito/index.html
kubotomo@geo.kyushu-u.ac.jp

Title of Project : Strategic research to construct motivic units using new symmetry

Kenichi Bannai
(Keio University, Faculty of Science and Technology, Professor)

Research Project Number : 18H05233 Researcher Number : 90343201
Keyword : Number Theory, Arithmetic Geometry

【Purpose and Background of the Research】

Conjectures such as the Beilinson conjecture, Tamagawa Number Conjecture and Iwasawa main conjecture concerning the special values of Hasse-Weil L-functions associated to algebraic variety defined over number field is a central problem in Mathematics, especially in arithmetic geometry. The Birch and Swinnerton-Dyer Conjecture for elliptic curves is a special case of these conjectures.

When the algebraic variety is the multiplicative group, whose associated Hasse-Weil L-function is the classical Riemann Zeta function, the above conjectures were solved by effort of many mathematicians a predominant tool being a motivic unit called the cyclotomic element (cyclotomic unit). One reason that the proof of the conjectures in the other cases are notoriously difficult is that there are no known method to systematically construct motivic units which intrinsically contain information concerning both the special values of the L-function and arithmetic information of the algebraic variety.

The purpose of this research is to study the polylogarithm, which are motivic elements systematically constructed for the multiplicative group, elliptic curves, and more general higher dimensional abelian varieties, wtih an eye towards future construction of motivic units. A concrete goal is to study the polylogarithm for a certain algebraic torus, and attempt to relate its Hodge realization to special values of L-function relevant in this case.

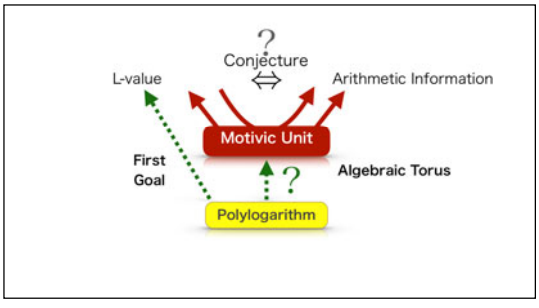


Figure 1 Concept

【Research Methods】

The research will be conducted by a team of experts including S. Yamamoto and S. Yasuda (Number Theory), S. Kobayashi (Iwasawa Theory), T. Terasoma (Motives), A. Shiho (p-adic theory) and T. Katsura (Operator Algebra). In particular, we will use techniques developed to explicitly represent higher degree cohomology classes, In order to obtain L-values from higher degree cohomology classes, it is necessary to use a theory of new symmetry called plectic structure developed by J. Nekovář and A. J. Scholl. We will first expand the theory of plectic structures for the Hodge case, and then will subsequently deal with the motivic, p-adic and étale cases.

【Expected Research Achievements and Scientific Significance】

If we succeed in explicitly determining the Hodge structure of the polylogarithm of the algebraic torus and succeed using the plectic structure to recover special values of the relevant L-function, then this would indicate the possibility that polylogarithm of the algebraic torus may be used to construct motivic units in this case.

【Publications Relevant to the Project】

- J. Nekovář and A. J. Scholl, *Introduction to plectic cohomology*, Advances in the theory of automorphic forms and their *L*-functions, Contemp. Math., vol. **664**, Amer. Math. Soc., Providence, RI, 2016, pp. 321–337.
- K. Bannai, K. Hagihara, S. Kobayashi, K. Yamada, S. Yamamoto, and S. Yasuda, *Category of mixed plectic Hodge structures* (2017), arXiv:1705.05522[math.AG].

【Term of Project】 FY2018-2022

【Budget Allocation】 91,900 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.math.keio.ac.jp/~bannai/
bannai@math.keio.ac.jp

Title of Project : High Precision Polarimetric Observation by a Balloon-Borne Solar Telescope: Revealing Conversion Processes of Magnetic Energy in the Stellar Atmosphere

Yukio Katsukawa
(National Institutes of Natural Sciences, National Astronomical Observatory of Japan, Solar Science Observatory, Associate Professor)

Research Project Number : 18H05234 Researcher Number : 00399289
Keyword : Astrophysical Plasma, Solar Physics, Optical-IR Astronomy, Balloon instrument, International Collaboration

【Purpose and Background of the Research】

The **chromosphere** interfacing the photosphere of 6000K and the corona of over 1MK is not a simple intermediate atmospheric layer transmitting magnetic energy, but a region where strong non-linearity drives dynamic phenomena, such as turbulence, shocks, and jets. Because the dynamics are likely to be responsible for injection of non-thermal energies into the corona and the solar winds, the chromosphere is the most important target in the solar and stellar physics. In order to **understand the conversion process of the magnetic energy**, it is necessary to quantitatively observe the chromosphere together with energy generation by turbulent magneto-convection in the photosphere. In order to overcome the qualitative interpretation by conventional imaging observations, we acquire a **high-quality 3D magnetic and velocity fields for the first time by the SUNRISE balloon-borne solar telescope**. In this research, we develop a high precision spectro-polarimeter to be installed in SUNRISE. In addition, we carry out **numerical modeling of the dynamic phenomenon in the solar atmosphere**, and aim to clarify the conversion process of magnetic fields in the astrophysical plasma by direct comparison with the 3D data provided by the SUNRISE balloon observation.

【Research Methods】

(1) High resolution and precise polarization measurement by the balloon-borne solar telescope SUNRISE: SUNRISE is an international joint project equipped with a 1m optical telescope. It allows us to perform a seeing-free and continuous observation for a week in its flight from Sweden to Canada at an altitude higher than 35km. We will newly develop SCIP (SUNRISE Chromospheric Infrared spectro-Polarimeter) for precise spectro-polarimetric observation of NIR spectral lines sensitive to magnetic fields in the photosphere and the chromosphere. Its flight is planned for 2021. We aim to obtain temporal evolution of 3D magnetic and velocity structures, to capture propagation of MHD waves and a discontinuous magnetic structure suggestive of magnetic reconnection.

(2) Numerical modeling of the solar photosphere and chromosphere: We employ massive numerical simulations to reproduce key process responsible for the energy transfer and dissipation which are highly deviated from thermal equilibrium over multiple spatial and temporal scales. We plan to incorporate ionization and recombination of atoms by heating and cooling, because they are likely to affect the dynamic phenomena in the chromosphere. We apply state-of-the-art radiative transfer calculation to simulate polarized spectra radiated from the dynamic phenomena, which allows us to make direct comparison with the data taken by SUNRISE.

【Expected Research Achievements and Scientific Significance】

The Sun provides a unique site to deeply understand the conversion processes of magnetic energy by the observations with resolution, which can be applied in a wide range of astrophysical plasmas such as stellar winds and accretion disks where common processes are likely to work. Because a space-based spectro-polarimetry planned in 2020's is only SUNRISE, this research can provide the basis for a future large-scale satellite project by showing superiority of the observation.

【Publications Relevant to the Project】

・“Penumbral Microjets in Sunspot Chromospheres: Evidence of Magnetic Reconnection”, Katsukawa, Y., Astrophysics and Space Science Library, 449, 201 (2018).
・”SUNRISE: Instrument, Mission, Data, First Results”, Solanki, S., ApJL, 723, L127 (2010).

【Term of Project】

FY2018-2022

【Budget Allocation】

109,100 Thousand Yen

【Homepage Address and Other Contact Information】

https://hinode.nao.ac.jp/SUNRISE/
yukio.katsukawa@nao.ac.jp

Title of Project : Origin of hadron mass studied by the systematic measurement of spectral change of mesons in nuclei

Satoshi Yokkaichi
(RIKEN, Nishina Center, Senior Research Scientist)

Research Project Number : 18H05235 Researcher Number : 20360670
Keyword : Experimental Nuclear Physics, GEM, Electron ID Detector, Tracker, Chiral symmetry

【Purpose and Background of the Research】

We have already published on the signature of the spectral change of vector mesons (ρ, ω, ϕ) in nuclei in 2006-7, as results of the KEK-PS E325 experiment. These are phenomena interpreted as evidence of "the mechanism of hadron mass generation due to the spontaneous broken chiral symmetry", which is proposed by Nambu.

In order to confirm this study, we have proposed J-PARC E16. We will start the commissioning of detectors at the completion of the newly-built high-momentum beamline at J-PARC Hadron experimental facility. We will perform systematic measurements with the 10 times as much statistics as that of E325.

【Research Methods】

We construct the new spectrometer at the high-momentum beamline which is under construction now, and measure the electron-positron pairs from the vector-meson decays. We radiate the primary proton beam (30 GeV, 1 x 10^{10} protons/pulse) from the J-PARC MR to very thin targets (C 400 μm, Cu 80 μm, Pb 30 μm), whose radiation length is up to 0.5% to suppress the electron background from the target material. To cope with the high interaction rate up to 1 x 10^{7} Hz at the target, we use GEM Tracker, which achieves the 100 μm of position resolution in tests, thus the evaluated mass resolution is 6-8 MeV for ϕ mesons. With the combination of two stage of electron identification detectors, Hadron Blind Gas Cherenkov Detector and Lead-glass calorimeter, we can reject background pions down to 0.03%.

【Expected Research Achievements and Scientific Significance】

As a model-independent analysis, we compare the measured invariant mass distribution of mesons with the vacuum-expected shape and difference between the two will be examined systematically. The amount of difference could be depend on the meson velocity and nuclear size, namely, the number of modified meson could be much for more slowly-moving mesons and for larger nuclei, where the probability of inside-nuclear decay is expected higher. Statistically-significant such dependences are the evidence of the spectral change of mesons in nuclei. Such analysis performed for the ϕ meson and ρ/ω mesons.

Also, we compare the data with theoretical calculations of spectral change. Once we reproduce the data shape by fitting with a model calculation, mass change of mesons at the normal nuclear density could be deduced. Particularly, mass change of ϕ meson is interpreted to the strange quark-antiquark pair condensate in nuclear matter, which is an order parameter of the chiral symmetry breaking, using in-medium QCD sum rules. Further, a momentum dependence of such mass is a dispersion relation of mesons in nuclear matter.

Namely, we re-confirm the existence of spectral change of mesons in nuclei and compare the nature of spectral change with the QCD predictions. That is an experimental elucidation of the nature of hadron as the elementary excitation on the QCD vacuum.

【Publications Relevant to the Project】

・"Evidence for In-Medium Modification of the φ meson at Normal Nuclear density", R. Muto et al. Phys. Rev. Lett. 98 (2007) 042501
・ "Experimental signature of the medium modification for rho and omega mesons in 12-GeV p+A reactions", M. Naruki et al. Phys. Rev. Lett. 96 (2006) 092301
・"In-medium mass modification of vector mesons", S. Yokkaichi, Lecture notes in physics 781 (2009) pp161-193, Springer

【Term of Project】 FY2018-2022

【Budget Allocation】 150,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://ribf.riken.jp/~yokkaich/E16/E16-index.html

Title of Project : From Quarks to Neutron Stars: Challenges in QCD

Tetsuo Hatsuda
(RIKEN, Interdisciplinary Theoretical and Mathematical Sciences, Program Director)

Research Project Number : 18H05236 Researcher Number : 20192700
Keyword : Neutron star, Lattice QCD, Baryon force, Quantum many-body problem, Equation of state

【Purpose and Background of the Research】

Structure of dense matter is one of the most important unsolved problems in nuclear physics. The coalescence of binary neutron stars (GW 170817) was recently observed by the gravitational wave and electromagnetic waves simultaneously. Understandings of high-density matter inside the neutron star and the origin of heavy elements will be further accelerated by such observations in the future.

The purpose of the present project is to derive the equation of state of dense matter through the precision quantum many-body calculations combined with the baryon-baryon interactions extracted from quantum chromodynamics (QCD) simulations on the lattice.

【Research Methods】

Reseachers participating in this project have pioneered the HAL QCD method for deriving the nuclear force from lattice QCD and also have developed the cluster variation method for quantum many-body systems. We will carry out systematic calculations of the baryon-baryon interactions as well as detailed studies of the three-body interactions by using lattice QCD simulations. This will provide basic data necessary to formulate the equation of state relevant to outer and inner cores of neutron stars. Also, we construct the equation of state at finite temperature with arbitrary proton fraction by the cluster variational method.

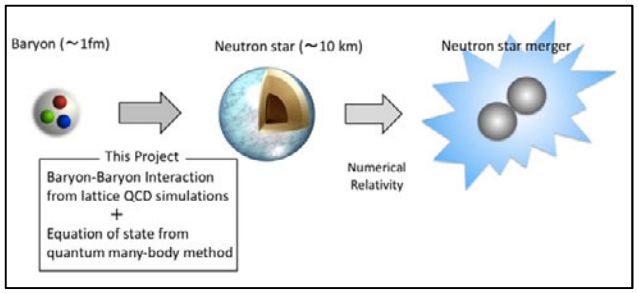


Figure 1 From quarks to neutron star mergers

【Expected Research Achievements and Scientific Significance】

Combining lattice QCD and quantum many-body method to construct a microscopic equation of state is crucial for analyzing gravitational wave from neutron star mergers. In addition, the present project is closely related to condensed matter physics for strongly correlated quantum systems such as cold atomic gases and liquid helium. The present project is also related directly to the experimental studies of dense matter using the collisions of heavy nuclei.

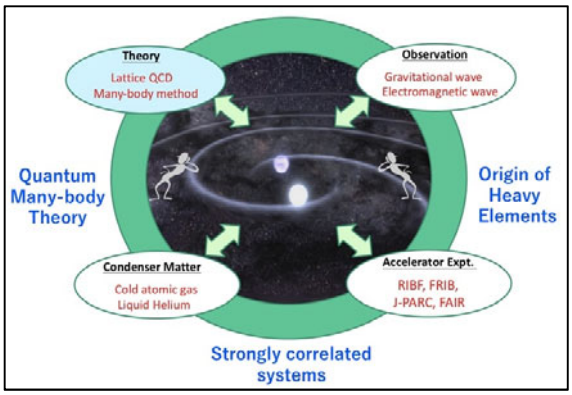


Figure 2 Interdisciplinary connections

【Publications Relevant to the Project】

・G. Baym, T. Hatsuda, T. Kojo, et. al, “From Hadrons to Quarks in Neutron Stars”, Rept. Prog. Phys. vol.81, 056902 (2018).
・H. Togashi, E. Hiyama, Y. Yamamoto, M. Takano, “Equation of State for Neutron Stars with Hyperons by the Variational method”, Phys. Rev. C93, 035808 (2016)

【Term of Project】 FY2018-2022

【Budget Allocation】 91,600 Thousand Yen

【Homepage Address and Other Contact Information】

https://ithems.riken.jp/
thatsuda@riken.jp

Title of Project : Information communication technology ensuring the long term security over a century

Akihisa Tomita
(Hokkaido University, Graduate School of Information Science and Technology, Professor)

Research Project Number : 18H05237 Researcher Number : 60501434
Keyword : Information theory, network, cryptography

【Purpose and Background of the Research】

Recently, our society is getting to rely on the electronic data that should be kept secret for a long period. For example, genome information, should be stored securely for more than human lifetime, *i.e.*, a hundred years. However, modern cryptographic protocols have been periodically updated to keep security. The present cryptographic technology can hardly guarantee the secrecy over a century.

This project therefore is aimed to develop an information theoretically secure storage, the security of which will never compromised by any technological progress. We combine secret sharing and quantum cryptography to achieve the information theoretical security.

【Research Methods】

Figure 1 depicts the network scheme developed in this project. Secret-sharing servers provide network functions such as multi-user management, synchronization and secret computing. Short distance high speed quantum key distribution (QKD) links provide secure communication between a server and a user and between servers. Even distant users can access the data securely through the user authentication with a password shared with a long distance (loss tolerant) QKD link.

The project contains four subjects: network construction and control, long distance QKD, high speed QKD, and theories on security certification and efficient key generation. The first half of the project will devote to examine candidates to achieve the project goal. Then, in the second half, we develop the devices and software to integrate the secure storage network.

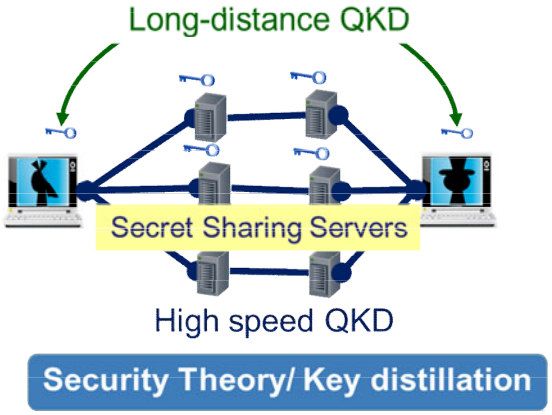


Figure 1 Information theoretically secure storage network

【Expected Research Achievements and Scientific Significance】

The project will realize an information communication and storage network secure against any possible attacks for over a century. This goal will be achieved by our newly developing technology combining the information theoretical secure modern cryptography and QKD. We will establish the technological frame work to construct practically useful combination.

The technological elements developed in the project, such as the optical pulses synchronization and precise control of the phase and frequency, will also advance the coherent optical communication.

【Publications Relevant to the Project】

K. Nakata, A. Tomita, M. Fujiwara, K. Yoshino, A. Tajima, A. Okamoto, and K. Ogawa," Intensity fluctuation of a gain-switched semiconductor laser for quantum key distribution system," Optics Express, **25**, 622-634 (2017)

M. Fujiwara, A. Waseda, R. Nojima, S. Moriai, O. Wakaha, and M. Sasaki, "Unbreakable distributed storage with quantum key distribution network and password authenticated secret sharing," Scientific Reports, 6: 29988 (2016).

【Term of Project】 FY2018-2022

【Budget Allocation】 148,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.eng.hokudai.ac.jp/labo/hikari/index.htm

【Grant-in-Aid for Scientific Research (S)】

Broad Section C

Title of Project : Study on digital frontier photonic sensing based on omnipotent fiber lasers

Shinji Yamashita
(The University of Tokyo, Research Center for Advanced Science and Technology, Professor)

Research Project Number : 18H05238 Researcher Number : 40239968
Keyword : Sensing devices, Signal processing

【Purpose and Background of the Research】

In future Society 5.0, mutual interactions between physical space and cyber space are expected to create new industry/service. There, sensing technologies are indispensable.

In this project, we aim at realizing omnipotent fiber lasers, and the innovative digital frontier photonic sensing by integrating the omnipotent fiber lasers and digital coherent signal processing technologies, as depicted in Fig.1.

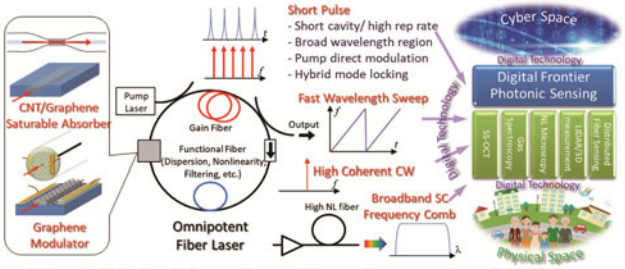


Fig.1 Digital frontier photonic sensing based on omnipotent fiber lasers

【Research Methods】

This project is based on our two original technologies. One is the passively mode-locked fiber lasers using carbon nanotube (CNT) and graphene. CNT and graphene are ultrafast, nano-size, and low-cost saturable absorbers, compatible with fiber/waveguide, and features broad wavelength operation. The other is the dispersion tuned actively mode-locked fiber lasers, which can sweep lasing wavelength with the use of active mode locking and fiber dispersion. It does not require any optical filters, as the result not limited by the speed or bandwidth of optical filters.

We have been developing omnipotent fiber lasers, as shown in Fig.1, which are actively or passively mode-locked fiber lasers having, not only intense short pulse output, but also digital features and high functionalities, such as, high repetition rate, broad bandwidth, and fast sweep, by fully utilizing functional (dispersion, nonlinearity, etc.) fibers. Omnipotent fiber lasers elicit various high functionalities in lasers from a single technique, mode locking.

Here we promote digital frontier photonic sensing. In the conventional analog photonic sensing, physical quantities are measured by interference of laser light beams in free space, and only the amplitude of interfered signals is processed in analog circuits. By contrast, in digital frontier photonic sensing, they are measured not only in free space but also in waveguides or fibers, and both amplitude and phase of interfered signals are digitally processed using digital coherent receivers. The digital signals are processed further with higher-level processing, such as compressed sensing or deep learning, to bridge between physical and cyber spaces. Thus, it is an innovative photonic sensing technology that fully utilizes lasers with digital features and high functionalities, and digital signal processing.

【Expected Research Achievements and Scientific Significance】

By applying the digital frontier photonic sensing to various sensings, such as optical coherence tomography (OCT), gas spectrometry, nonlinear microscope, LIDAR/3D measurement, and optical fiber sensors, as listed in Fig.1, we expect to contribute to realization of Society 5.0.

【Publications Relevant to the Project】

・S. Yamashita, A. Martinez, and B. Xu, “Short pulse fiber lasers mode-locked by carbon nanotube and graphene (Invited),” Optical Fiber Technology, vol.20, no.6, pp.702-713, Dec. 2014.
・S. Yamashita, “Dispersion-tuned swept lasers for optical coherence tomography (Invited),” IEEE Journal of Selected Topics in Quantum Electronics, vol.24, no.3, 6800109, May 2018.

【Term of Project】 FY2018-2022

【Budget Allocation】 144,800 Thousand Yen

【Homepage Address and Other Contact Information】

http:// www.cntp.t.u-tokyo.ac.jp

Title of Project : Development of crust imaging enhanced by hetero-computing for reducing earthquake disaster

Tsuyoshi Ichimura
(The University of Tokyo, Earthquake Research Institute, Associate Professor)

Research Project Number : 18H05239 Researcher Number : 20333833
Keyword : Earthquake engineering, Earthquake disaster mitigation, Applied mechanics, Computer science

【Purpose and Background of the Research】

The goal of this study is to develop next-generation crustal imaging methods for estimating crustal structure, source area state, etc. for earthquake disaster mitigation through a combination of cutting-edge computational science and observations. Although the recent development of seismological and geodetic observations (e.g., observations of the ocean bottom just above the offshore source area of megathrust earthquakes) has increased the possibility of developing such imaging methods, they remain difficult to realize due to the huge analysis cost. In this study, we aim to realize crustal imaging methods by using a heterogeneous computing approach. Furthermore, using the developed methods and real observation data, we will attempt to perform crustal imaging of real targets.

【Research Methods】

Prof. Tsuyoshi Ichimura's group will develop an optimization method based on an ultra-high-speed computing method for seismic waves and crustal deformation, using heterogeneous computing and a large-scale finite element method. These methods will be implemented in a heterogeneous computing environment and their effectiveness will be investigated. Dr. Takane Hori's group will develop a method to assimilate on- and offshore crustal data and a model of spatiotemporal variation in the source area. Furthermore, the methods developed by Prof. Ichimura's group will be introduced stepwise to construct a prototype of a crustal imaging system with the aim of conducting crustal imaging using real observation data.

【Expected Research Achievements and Scientific Significance】

Earthquake damage estimation is important for mitigating earthquake disasters. To estimate the damage, information about the crustal structure and source area state is of fundamental importance. This study aims to improve the reliability of such information by combining cutting-edge computational science and observations. Hence, a substantial contribution toward earthquake disaster mitigation is expected.

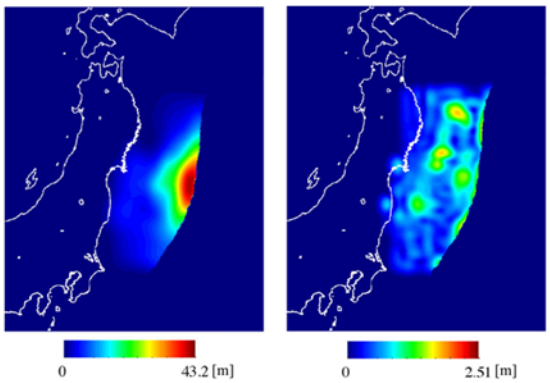


Fig: Example of the fault slip distribution considering the uncertainty of the crust structure (left: mean, right: deviation).

【Publications Relevant to the Project】

・Ichimura, T., Fujita, K., Quinay, P. E. B., Maddegedara, L., Hori, M., Tanaka, S., Shizawa, Y., Kobayashi, H. and Minami, K., Implicit Nonlinear Wave Simulation with 1.08T DOF and 0.270T Unstructured Finite Elements to Enhance Comprehensive Earthquake Simulation, SC15: International Conference for High Performance Computing, Networking, Storage and Analysis, Article No. 4, 2015.
・Hori, T., Hyodo, M., Nakata, R., Miyazaki, S., Kaneda, Y., A forecasting procedure for plate boundary earthquakes based on sequential data assimilation, Oceanography, 27, 2, 94-102, 2014.

【Term of Project】 FY2018-2022

【Budget Allocation】 144,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.eri.u-tokyo.ac.jp/sensing_and_simulation/index.html
http://www.jamstec.go.jp/ceat/e/etfsrg/

【Grant-in-Aid for Scientific Research (S)】

Broad Section C

Title of Project : Ultimately-Time-Resolved Imaging Devices Using Ultrafast Hybrid Cascade Photo-Charge Modulators and Their Applications

Shoji Kawahito
(Shizuoka University, Research Institute of Electronics, Professor)

Research Project Number : 18H05240 Researcher Number : 40204763
Keyword : Time-resolved imaging, photo-charge modulator, Biomedical imaging, Time-of-flight imaging

【Purpose and Background of the Research】

In this study, we investigate ultimately time-resolved imaging devices for detecting very weak light, non-visible light or very weak light under a strong ambient light and their applications. A new high-speed photo-charge modulator so-called the HyCAM (Hybrid cascade photo-charge modulator) is proposed for the visible and near-infrared ultra-highly time-resolved imaging particularly with multiple-window time-resolved pixels. The purpose of this study is to demonstrate the significance of the HyCAM in biological, medical, scientific and industrial applications by actually using the implemented time-resolved image sensors.

【Research Methods】

The HyCAM is a high-speed highly-sensitive low-noise charge modulation device that uses both vertical electric field created by tapped p+ electrodes in a pinned photodiode and lateral electric field created by a set of gates arranged along the channel of photo-carrier transportation and is suitable for large-aperture multiple-window time-resolved pixels. To investigate the optimal structures and dimensions and a new function of the HyCAM pixels, a test element group of the HyCAM pixels with different designs and parameters and 2D pixel arrays or time-resolved image sensors (TRISs) will be implemented and characterized. The implemented TRISs are used for a FLIM (fluorescence lifetime imaging microscopy) -based biomedical imaging for tumor detection, spatial- and time-resolved NIRS (near infrared spectroscopy) for monitoring brain activity, a SRS (stimulated Raman spectroscopy)-based unstained bio-imaging, and extremely depth-resolved TOF (time of flight) range image sensors in order to investigate what new values and findings are obtained by the TRIS chips.

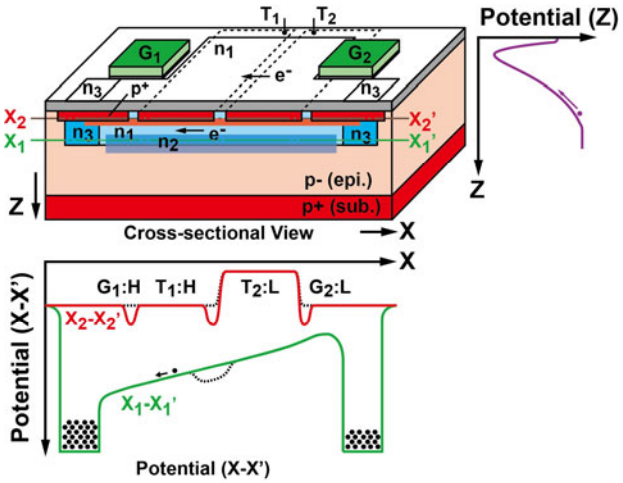


Figure 1 Hybrid cascade photo-charge modulator.

【Expected Research Achievements and Scientific Significance】

The HyCAM and TRISs using the HyCAM pixels will bring a significant paradigm shift in time-resolved imaging system concept from a spatial- and time-scanning based system to spatially-parallel (pixel-array) and multiple-window time-resolved pixel based system. This semiconductor-based system will be one of key technologies in next-generation biological, medical, scientific and industrial imaging tools.

【Publications Relevant to the Project】

・M.-W. Seo, Y. Shirakawa, Y. Kawata, K. Kagawa, K. Yasutomi, S. Kawahito, "A time-resolved four-tap lock-in pixel CMOS image sensor for real-time fluorescence lifetime imaging microscopy", IEEE J. Solid-State Circuits, pp.1-12, vol.53, 2018.
・D. X. Lioe, K. Mars, S. Kawahito, M. Hashimoto, "A stimulated Raman scattering CMOS pixel using a high-speed charge modulator and lock-in amplifier," Sensors, vol. 16, pp.532-547 , 2016.

【Term of Project】 FY2018-2022

【Budget Allocation】 147,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.idl.rie.shizuoka.ac.jp/
kawahito@idl.rie.shizuoka.ac.jp

Title of Project : Design on Mechanical and Multi-Physics Properties of Nano-Structured Meta-Interface

Takayuki Kitamura
(Kyoto University, Graduate School of Engineering, Professor)

Research Project Number : 18H05241 Researcher Number : 20169882
Keyword : Nano-structure, Meta-interface, Mechanics, Multi-physics, Design

【Purpose and Background of the Research】

As a small device consists of many kinds of materials, dissimilar interfaces are inevitably included inside it. The material properties at interfaces are inferior in general. This project aims to investigate novel properties of nano-structured meta-interface on the basis of inquiry of their mechanisms in detail, and to contribute the innovative design of devices.

(1) We develop a methodology to examine the mechanical properties of a nanometer-scaled (10-30nm) element, which composes the meta-interface, and evaluate the effect of geometry and size of single element.
(2) Considering the interaction, we design the mechanical function of meta-interface. We experimentally examine it as well.
(3) We develop a methodology to examine the multi-physics (ferro-magnetics, ferro-electrics, mechanics and so on) properties of the nanometer-scaled element and investigate the characteristics of meta-interface.

【Research Methods】

We have a technique to make a layer composed of numerous nanometer-scaled elements by a dynamic oblique deposition method. The shape and size of elements can be precisely controlled (sculptured nano-elements; see Fig. 1). The nano-structured meta-interface can be formed by the method and we recently get some clues of innovative functions by preliminary investigations. Thus, we will develop equipment to examine the mechanical behavior of nano-elements (Fig.2) and will inquire the property of the interface. Then, by the first principle simulation and conversion of equipment, we will extend our challenge toward the multi-physics properties of nano-structured meta-interface.

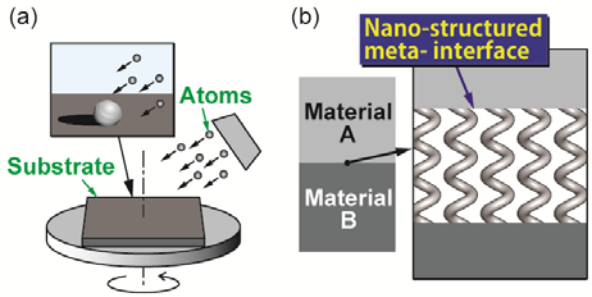


Figure 1 (a) Dynamic oblique deposition, (b) Nano-structured meta-interface.

【Expected Research Achievements and Scientific Significance】

While a dissimilar interface in a device has been considered as weak point in general, we can introduce innovative mechanical properties by this research exploring mechanics on deformation of nano-elements and interactions among numerous elements.

We extend the function to multi-physics properties in nanometer scale. We try to establish a new scientific field; mechanics and multi-physics in assembled nano-structures.

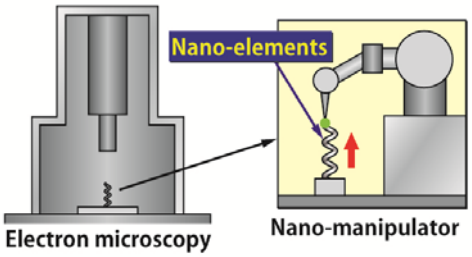


Figure 2 Equipment to examine the mechanical behavior of nano-elements.

【Publications Relevant to the Project】

T. Kitamura, T. Sumigawa, H. Hirakata and T. Shimada, "FRACTURE NANOMECHANICS" 2nd Edition (Pan Stanford Publishing Pte. Ltd., (2016)), ISBN 978-981-4669-04-7.
Y. Umeno, T. Shimada, Y. Kinoshita and T. Kitamura, "MULTIPHYSICS IN NANOSTRUCTURES" (Springer, (2017)), ISBN 978-4-431-56571-0.

【Term of Project】 FY2018-2022

【Budget Allocation】 150,700 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.me.t.kyoto-u.ac.jp/ja/research/introduction/zairyoubussei

Title of Project : Dynamical flow control of nanoparticles by machine learning and its application to single molecule identification technologies

Satoyuki Kawano
(Osaka University, Graduate School of Engineering Science, Professor)

Research Project Number : 18H05242 Researcher Number : 00250837
Keywords : Molecular fluid dynamics, Nanoparticles, Single molecule measurement, Machine learning

【Purpose and Background of the Research】

In this project, we aim to comprehensively investigate the flow dynamics of ions, molecules and charged particles in the presence of electromagnetic fields, and to pioneer new research areas. As shown in Figure 1, our approach integrates thermal fluctuations, large deviation principles, thermophoresis, optical pressure, electrophoresis, quantum electronics and machine learning into the field of molecular fluid dynamics. Our practical challenge will be the development of a novel fluidic device with sensing nanogap electrodes for identifying nanoparticles.

【Research Methods】

This project will consist of three different research topics. The first involves the identification of single molecules using a statistical approach to thermal fluctuations. We will define additional dynamics parameters that extend the scope of the fluctuation-dissipation theorem. Novel methods for evaluating and controlling rare events will be developed based on large deviation principles. The second research topic addresses high-speed measurement of the tunneling current between nanogap electrodes, which is a quantum mechanical effect, by sensing nanoparticle flow in a liquid phase based on multiscale electrohydrodynamics (EHD). We intend to establish in situ feedback control of an EHD flow and to design optimized fluidic channels using machine learning. The final research topic involves manipulation of individual molecules using laser irradiation. The application of optical pressure to drive nanoparticles towards nanogap electrodes will be investigated for the purpose of achieving a higher yield. The thermophoretic force, which can act in a positive or negative direction, and is still not fully understood, will also be utilized. In the second half of the research period, all of the results obtained will be combined in order to develop a micro/nano-fluidic device with embedded nanogap electrodes.

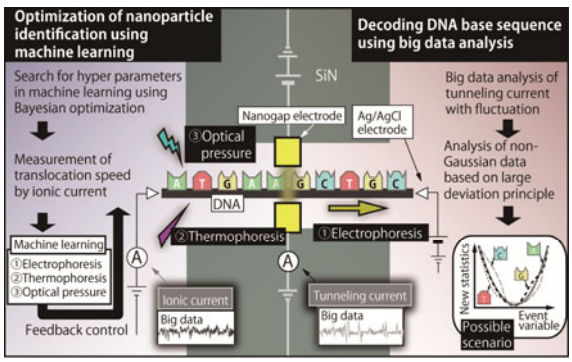


Figure 1 Overview of fluidic device for identifying pollen allergens, viruses, and DNA molecules

【Expected Research Achievements and Scientific Significance】

By integrating quantum electronics, life sciences, statistical mechanics and information technology into micro/nano fluid engineering, we expect to establish a new academic field called "Molectro-Fluid Science and Informatics," and develop new techniques for measuring single molecules utilizing fluidic devices. Such devices can be used for high-speed identification of micro/nano-particles such as pollen allergens, viruses, and DNA molecules.

【Publications Relevant to the Project】

・C. Kawaguchi, T. Noda, M. Tsutsui, M. Taniguchi, S. Kawano, T. Kawai, Electrical Detection of Single Pollen Allergen Particles Using Electrode-Embedded Microchannels, **J. Phys.: Condens. Matter**, 24, 164202, 2012.
・I. Hanasaki, N. Yukimoto, S. Uehara, H. Shintaku, S. Kawano, Linearisation of λDNA Molecules by Instantaneous Variation of the Trapping Electrode Voltage Inside a Micro-Channel, **J. Phys. D**, 48, 135402, 2015.

【Term of Project】

FY2018-2022

【Budget Allocation】

119,000 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Fundamental Study of Robust Molecule Recognition Electronics

Takeshi Yanagida
(Kyushu University, Institute of Material Chemistry and Engineering, Professor)

Research Project Number : 18H05243 Researcher Number : 50420419
Keyword : Nanomaterials, Molecule Recognition, Electronics

【Purpose and Background of the Research】

Sensor electronics that measures our personal information in "long term" and accumulate in cyberspace opens up new academies and industries. Currently, a robust physical sensor is the mainstream of its research, but molecular sensor electronics that distinguishes "chemical" molecular information (biological gas etc.) in the long term "electric" is still limited. In this research, we develop "robust molecular sensor electronics" as a bridge of chemical information between real world and cyber space around us by metal oxide nanowire interface with molecular identification function and integrated hybrid molecular sensor.

【Research Methods】

Using a group of volatile molecules in exhaled breath as a target, we investigate the molecule's information on the surface of oxide nanowire surfaces including 1) functional groups (alcohols, aldehydes, ketones, carboxylic acids, amines), 2) molecular weight, 3) structural isomers, in order to verify the molecular recognition ability. As a verification method, the influence of these molecular skeleton parameters on molecular recognition ability (GC-MS desorption spectral analysis) is analyzed by the solid surface structure (TEM analysis, Raman spectroscopy) and molecular adsorption state (infrared spectroscopic pMAIRS method) In consideration of the information on the information. As a different approach, when a shell layer of core / shell nanowire structure is formed, a target molecule is interposed and a nanowire surface storing the molecular shape is formed. With this method, it becomes possible to conduct experiments in a wider crystal growth atmosphere beyond the framework of anisotropic crystal growth, and it is expected that the range of applicable molecular species can be expanded.

By examining the temperature dependence, we verify the robustness of nanowire molecule identification function and its mechanism. Physical properties responsible for robustness are bond energies of metal ions and oxygen ions in oxides. An oxide nanowire having a molecular recognition function is formed as an integrated hybrid molecular sensor on a silicon substrate by utilizing a space selective crystal growth technique. I) an oxide nanowire structure as a molecular collector having a molecular recognition function and ii) a structure in which a current detection sensor part is hybrid arrayed on a micro / nanoscale. Regarding the molecular recognition ability, we will also consider improving the recognition ability by controlling the adsorption temperature in addition to the desorption temperature. Electrical molecular discrimination is carried out using various integrated hybrid molecular sensors fabricated for the aforementioned target molecule mixture. We demonstrate further improvement of molecular discrimination ability by multiplying the molecular discrimination ability on the oxide nanowire surface by the discrimination ability at the sensor part.

【Expected Research Achievements and Scientific Significance】

"Rigid" oxide nano surface spreads to research fields that distinguish "soft" molecular shape, and not only sensor research but also a wide spread effect on molecular selective catalyst research field is expected. By utilizing its robustness, deployment to an IoT molecular sensor that enables constant breath diagnosis by smartphones and the like is a major industrial development.

【Publications Relevant to the Project】

・Nanoscale Thermal Management of Single SnO_2 Nanowire: pico-Joule Energy Consumed Molecule Sensor, G.Meng, F.Zhuge, K.Nagashima, A.Nakao, M.Kanai, Y.He, M.Boudot, T.Takahashi, K.Uchida and T.Yanagida, ***ACS Sensors***, 1, 997 (2016).
・Long-Term Stability of Oxide Nanowire Sensors via Heavily-Doped Oxide Contact, H.Zeng, T.Takahashi, M. Kanai, G.Zhang, Y.He, K.Nagashima and T.Yanagida
ACS Sensors, 2, 1854 (2017). *Cover of ACS Sensors*

【Term of Project】 FY2018-2022

【Budget Allocation】 150,200 Thousand Yen

【Homepage Address and Other Contact Information】

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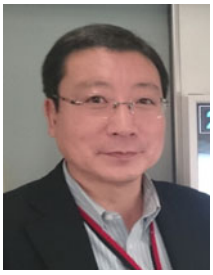
【Grant-in-Aid for Scientific Research (S)】

Broad Section C



Title of Project : Establishment of design principle and basic technology for next generation medical high temperature superconducting skeleton-cyclotron

Atsushi Ishiyama
(Waseda University, Graduate School of Science and Engineering, Professor)

Research Project Number : 18H05244 Researcher Number : 00130865
Keyword : Electrical machine, Superconducting material, Accelerator, Quantum beam, Cancer

【Purpose and Background of the Research】

For advanced cancer therapy, “targeted α-particle therapy" is very promising. To widely use the targeted–particle therapy, a large amount of Radio Isotope (^{211}At) which radiates α-rays must be stably produced. The final goal of this study is to develop an extremely compact and variable-energy HTS (High Temperature Superconducting) accelerator called “Skelton Cyclotron (HTS-SC)”. Until now, we have been working on the development of fundamental technologies that enable "5-High: high mechanical strength, high current density, high thermal stability, high magnetic field, and high precision magnetic field". In this research project, in order to realize a HTS multi-coil system for forming a magnetic field distribution indispensable for beam acceleration, we develop innovative magnet technology integrating the 5-High technology and we aim to establish the design principle and basic technology of HTS-SC.

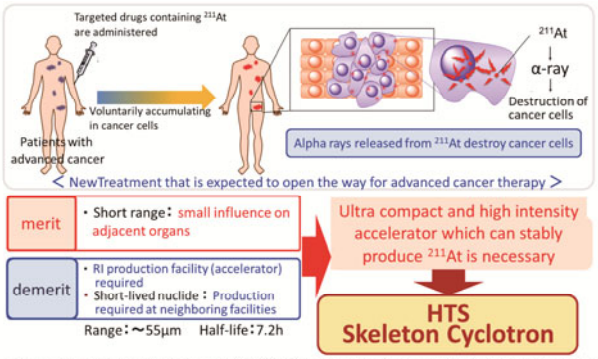


Figure 1 Targeted alpha-particle therapy and issues for dissemination

【Research Methods】

HTS-SC performs high “precision magnetic field necessary for beam acceleration with only a HTS multi-coil system consisting of air-core coils. As a result, in addition to reduction in size and weight, the magnetic field can be changed without being affected by the nonlinear magnetization characteristics of the iron core, and the output can be controlled. Therefore, multi-functionalization becomes possible. In this research, as innovative magnet technologies for the purpose of developing a multi-coil system for HTS-SC, 1)coil reinforcing structure for high mechanical strength, 2)technology to achieve both high current density and high thermal stability, 3)technology for generating high-precision magnetic field, and 4)optimal design technology of multi-coil system, will be established. And then, the feasibility and effectiveness (variable output energy) of HTS-SC will be demonstrated by a small model, "Baby HTS-SC coil system".

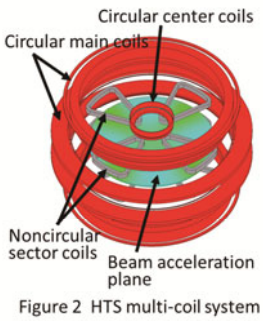


Figure 2 HTS multi-coil system

【Expected Research Achievements and Scientific Significance】

Through the development of HTS-SC, it can be expected to develop compact and lightweight heavy-particle accelerator for cancer treatment. Furthermore, if an innovative magnet technology is established, it can be applied to not only for medical use but also for unexplored stage applications such as coils for next generation compact nuclear fusion reactor and ultra-high density superconducting magnetic energy storage device.

【Publications Relevant to the Project】

・A.Ikeda et al., “Transient Behaviors of No-Insulation REBCO Pancake Coil during Local Normal-State Transition,” IEEE Transactions on Applied Superconductivity, Vol. 26, No. 4, 4600204, 2016
・H.Ueda et al., “Conceptual design of next generation HTS cyclotron” IEEE Transactions on Applied Superconductivity, Vol. 23, No.2, 4100205, 2014

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Development of new imaging technology based on superconducting single-photon camera

Hirotaka Terai
(National Institute of Information and Communications Technology, Advanced ICT Research Institute, Executive Researcher)

Research Project Number : 18H05245 Researcher Number : 10359094
Keyword : Single-photon detector, Image sensor, Superconducting digital signal processing

【Purpose and Background of the Research】

Photon detection technique with high spatial and temporal precision is fundamental in a wide range of fields such as quantum information and processing, quantum communication, photon spectroscopy, astronomical observation, bioimaging and so on. Cooled CCD is the most sensitive image sensor that can detect extremely weak light by a factor of 100 million lower than moonlight, but it still has several tens of thousands of photons per second. In addition, the sensitivity of CCD in near infrared region is not good enough, while the near infrared light is useful because it can penetrate deep inside the biological sample. Furthermore, the frame rate is also slow as several tens kHz even in high-speed electron multiplying CCD.

The superconducting nanowire photon detectors (SSPDs) have sensitivity in a wide spectral range from deep ultraviolet to mid infrared, and have been already used in many advanced experiments in quantum information field. The SSPD has detection efficiency over 90% at 1.55 μm, low dark count rate below 1 cps, excellent timing jitter below 20 ps. Photon imaging technology with a wide spectral range, ultra-low noise, high spatial and temporal resolution will be possible by realizing two-dimensional SSPD array, but the number of pixels demonstrated so far is as large as 64 due to the difficulty in signal readout.

【Research Methods】

We aim to realize a large-scale SSPD image sensor with the configuration shown in Fig. 1, where SSPD array with row-column readout scheme and a single flux quantum (SFQ) signal processing circuit are employed. We also introduce an adiabatic flux quantum parametron (AQFP) circuit in addition to the SFQ circuit to reduce the bias current, where the SFQ/AQFP hybrid signal processor will be fabricated by using the AIST Nb standard process. Our goal is to realize SSPD image sensor with 100 × 100 pixels and it will be applied to photon spectroscopy and bioimaging system.

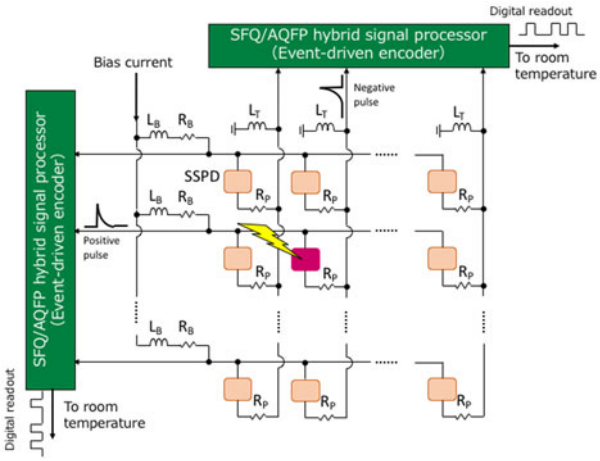

Figure 1 Configuration of superconducting single-photon image sensor

【Expected Research Achievements and Scientific Significance】

By realizing an image sensor with a photon countable sensitivity, extremely low noise, high spatial and temporal resolution with a wide spectral range from deep ultraviolet to mid infrared, it will be an innovative tool in various fields and make a big contribution to create new academies.

【Publications Relevant to the Project】

・N. Takeuchi, T. Yamashita, S. Miyajima, S. Miki, N. Yoshikawa, and H. Terai, Optics Express 25, 32650 (2017).
・H. Terai, S. Miki, and Z. Wang, IEEE Trans. on Supercond. 19, 350 (2009).

【Term of Project】 FY2018-2022

【Budget Allocation】 149,400 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Renaissance of Metallic Superlattices

Koki Takanashi
(Tohoku University, Institute for Materials Research, Professor)

Research Project Number : 18H05246 Researcher Number : 00187981
Keyword : Metallic superlattices, Spin-orbit interaction, Antiferromagnetic structure, Spin caloritronics

【Purpose and Background of the Research】

Metallic superlattices, where different metal layers are alternated periodically in a nanometer scale, were extensively studied for the giant magnetoresistance (GMR) effect and interlayer exchange coupling in 1980's-90's, giving the basis of spintronics. The recent progress of spintronics shows the following new developments: spin orbitronics incorporating spin-orbit interaction, antiferromagnetic spintronics utilizing the merits of antiferromagnets, and spin caloritronics based on the interplay between spin and heat. For these emerging research areas, the importance of interfaces has attracted much attention because of the possible enhancement of spin-orbit interaction at interfaces. The metallic superlattice as an assembly of interfaces will be useful for the systematic study of interface effects.

In this research project, as show in Fig. 1, we revisit metallic superlattices from the viewpoint of modern developments of spintronics. We aim to elucidate the role of interface on spin-orbit interaction by using metallic superlattices, demonstrate the spin-orbit torque switching in an antiferromagnetically-coupled superlattice, and fabricate a metallic superlattice showing a large thermo-magnetic effect and a small thermal conductivity.

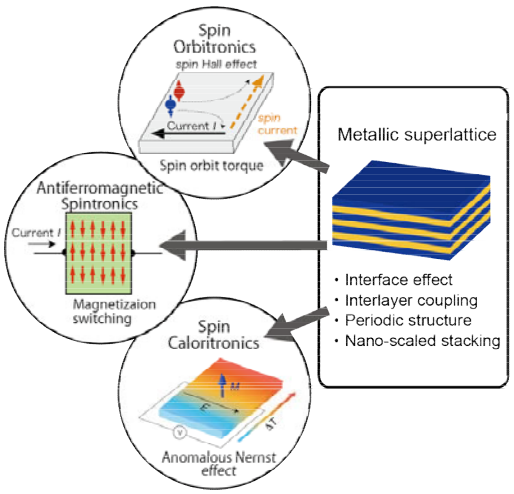

Fig. 1 Renaissance of Metallic Superlattices

【Research Methods】

For spin orbitronics, the layered structure of "Nonmagnet 1 / Ferromagnet / Nonmagnet 2" is used to evaluate interface magnetic anisotropy and spin-orbit torque simultaneously. The systematic study enables us to elucidate the mechanism of spin-orbit interaction at interfaces, leading to enhanced spin-orbit toque.

For antiferromagnetic spintronics, "Ferromagnet / Nonmagnet / Ferromagnet" is the basic layered structure. We aim to find a nonmagnetic material showing both strong antiferromagnetic interlayer coupling and large spin-orbit torque.

For spin caloritronics, we focus on the anomalous Nernst effect in metallic superlattices, and investigate a guiding principle for a high dimensionless figure of merit (ZT) by utilizing interface effect and nano-layering effect.

【Expected Research Achievements and Scientific Significance】

The observation of giant spin-orbit toque is expected due to the enhanced spin orbit interaction at interfaces in metallic superlattice, contributing significantly to the development of spin orbitronics. In addition, the study of spin caloritronics may open the application of metallic superlattice as a new thermo-electric material.

【Publications Relevant to the Project】

"Enhancement of anomalous Nernst effects in metallic multilayers free from proximity-induced magnetism", K. Uchida, T. Seki, K. Takanashi *et al.*, *Phys. Rev. B*, 92, 094414-1-6 (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 150,900 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Design and development of novel active sites on heterogeneous catalysts using direct interaction of molecules with solid surfaces

Keiichi Tomishige
(Tohoku University, Graduate School of Engineering, Professor)

Research Project Number : 18H05247 Researcher Number : 50262051
Keyword : Catalyst function, biomass, CO_2

【Purpose and Background of the Research】

Lots of chemicals have been produced from petroleum. From the viewpoint of CO_2 emission and limitation of petroleum, the technologies for the conversion of biomass and CO_2 are necessary for the sustainable society. Heterogeneous catalysts are more promising in terms of the catalyst separation and reusability. At the same time, the increase of the total energy efficiency can be enhanced by the replacement of present multi-step processes with one-pot conversion using heterogeneous catalysts, which is also connected to the decrease of CO_2 emission. The purpose of this research is to develop heterogeneous catalysts for the efficient conversion of biomass and CO_2 and to propose the design and preparation methods of catalytically active sites as a key of the catalyst development.

【Research Methods】

The aim of this study is to make the catalytically active site with high performance through the synergy of modifiers such as molecules or clusters and solid surfaces by the direct interaction. A typical example of the preparation of heterogenous catalyst is shown in Figure 1 (a).

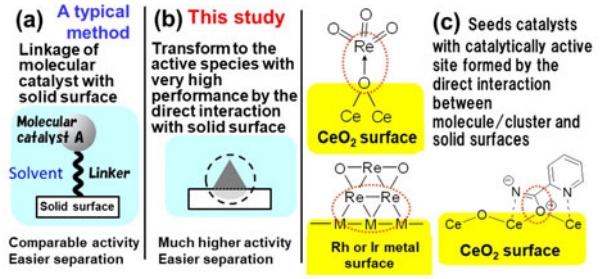

Figure 1. Preparation method of heterogeneous catalysts (a), (b) and seed catalysts prepared by the direct interaction between modifiers with solid surfaces (c)

In this study, we challenge to transform to the highly active species by the direct interaction with solid surfaces (Figure 1 (b)). The combination giving strong synergy is very limited. Broad and careful surveys have been essential in order to find an effective combination. In this study, the details of our seed catalysts are investigated using near-ambient pressure X-ray photoelectron spectroscopy combined with various characterization methods and computational chemistry.

【Expected Research Achievements and Scientific Significance】

Seed catalysts are isolated ReO_x species on CeO_2 surface for deoxydehydration, ReO_x clusters on Rh or Ir surfaces for C-O hydrogenolysis, and CeO_2+2-cyanopyridine for the conversion of CO_2+alcohols to organic carbonates (Figure 1(c)). These catalysts showed high performance in the production of value-added chemicals from biomass and CO_2, however, a problem is the usage of noble metals or complicated molecules. For the substitution with cheaper and more abundant metals or simpler molecules, different counter components can be found effectively on the basis of the results of the analyses of the seed catalysts. The development of catalysts without containing noble metals and complicated molecules can enhance the feasibility of the process remarkably.

【Publications Relevant to the Project】

・Transformation of Sugars to Chiral Polyols over a Heterogeneous Catalyst, M. Tamura, K. Tomishige, et al., Angew. Chem. Int. Ed., 57, 8058-8062 (2018)
・Self-Assembled Hybrid Metal Oxide Base Catalysts Prepared by Simply Mixing with Organic Modifiers, M. Tamura, K. Tomishige, et al., Nature Commun., 6, 8580 (2015)

【Term of Project】 FY2018-2022

【Budget Allocation】 146,900 Thousand Yen

【Homepage Address and Other Contact Information】

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【Grant-in-Aid for Scientific Research (S)】

Broad Section D

Title of Project : Magnet technology development for 50T cryogen-free high temperature superconducting magnet

Satoshi Awaji
(Tohoku University, Institute for Materials Research, Professor)

Research Project Number : 18H05248 Researcher Number : 10222770
Keyword : high temperature superconductors, superconducting magnet

【Purpose and Background of the Research】

More than 30 years past since the high temperature cuprate superconductor was discovered in 1986. Practical high temperature superconducting (HTS) wires are commercialized. Nowadays, many efforts are made for the development of HTS applications. In particular, high field magnets beyond 20 T using HTS are expected, because of those high performances in high magnetic field. However, it is difficult to realize a practical HTS high field magnet, since the magnet design concept for the HTS is much different with that of low temperature superconductor (LTS).

On the other hand, a cryogen-free superconducting magnet (CSM), which is cooled by cryocoolers conductively, is used widely. We recently developed a 25T-CSM with a HTS insert and achieved 24.6 T in a 52 room temperature bore.

In this study, we develop a new HTS magnet technology on the basis of the 25T-CSM, targeting a 50 T-class superconducting magnet. The world record of CSM will be broken by our obtained result.

【Research Methods】

We set four subjects as the HTS magnet technologies in order to generate a stable high magnetic field as follows.

1. Conduction-cooled coil fabrication technology without degradation
2. To understand a mechanical reinforcement and a deformation under a huge electro-magnetic stress
3. To understand a quench behavior and its protection
4. Ac-losses and field induced by the shielding current and coupling windings.

【Expected Research Achievements and Scientific Significance】

By a construction of new magnet technology model for high field HTS magnets, a route to 50 T-class superconducting magnet will be obtained. The world trend of high magnetic field is to achieve more than 40 T using a large electric power above 20 MW. However, we aim for corresponding high magnetic fields using the HTS magnet technologies obtained in this study. The stable and high precise high magnetic fields due to the superconducting magnet gives us new high magnetic field science. In addition, the HTS magnet technology impacts on various practical superconducting applications.

【Publications Relevant to the Project】

- S. Awaji et al., " First performance test of a 25 T cryogen-free superconducting magnet", Supercond. Sci. Technol. 30 (2017) 065001.
- S. Awaji et al., "10T generation by an epoxy impregnated GdBCO insert coil for the 25T-cryogen-free superconducting magnet" , Suprerocnd. Sci. Technol., 29 (2016) 055010.

【Term of Project】 FY2018-2021

【Budget Allocation】 146,100 Thousand Yen

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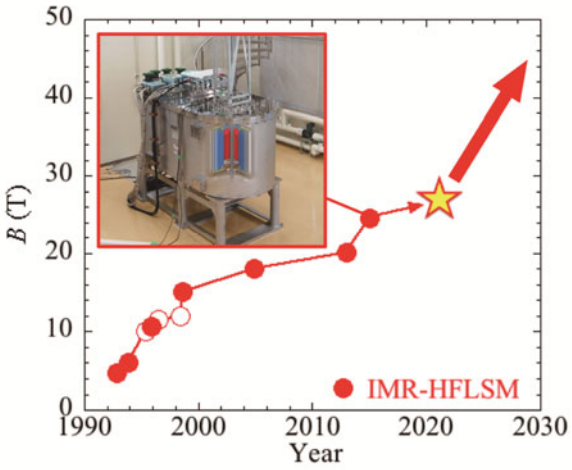

Fig. 1 Progress of cryogen-free superconducting magnet and project target.

Title of Project : Construction of new mechanism for dual-ion storage batteries concerted by lithium and multivalent ions

Tetsu Ichitsubo
(Tohoku University, Institute for Materials Research, Professor)

Research Project Number : 18H05249 Researcher Number : 40324826
Keyword : Polyvalent-ion conductivity, Concerted interaction, Dendrite free, Metal anode battery

【Purpose and Background of the Research】

Construction of energy storage technology is indispensable in the modern society. Although the mechanism of a storage battery using a monovalent carrier ion such as a lithium ion battery is well known or understood, the basic science of storage batteries system using multivalent ions such as magnesium as a carrier is almost unknown. We have been making efforts to develop positive electrode materials for magnesium storage batteries that utilize divalent carriers earlier and succeeded in proposing several potential candidates as positive electrode materials for magnesium storage batteries. We have also pioneered to propose the concept of dual-carrier rechargeable batteries that simultaneously utilize monovalent ions and divalent ions so far. Therefore, in this research, we aim to establish the material science for storage batteries that utilize multivalent ions as carriers and to construct the theory/concept of cooperative collaborations, i.e., concerted interaction, played between Li and multivalent careers.

【Research Methods】

The fundamental problems to be solved in this research are as follows.

[1] Coherent strain-field effect due to phase transition: While a phase transition occurs along with the insertion and extraction of carrier ions, the coherent strain field yielded by lattice mismatch greatly affects electrode characteristics. Evaluation of the strain field is carried out by scanning / transmission electron microscope, soft X-ray spectroscopy, synchrotron radiation or X-ray diffraction analysis, and the strain energy is evaluated by the first principles calculation, micromechanics calculation.

[2] Elucidation of concerted effects between dual ions: We have found that the activation energy of diffusion is markedly reduced under the dual-career situation, as shown in Fig. 1, by using first principles calculations. So, we try to clarify such “concerted interaction” between monovalent and multivalent ions. As a final goal, we try to find a mechanism by which multivalent ions can move even at room temperature.

[3] Proposal of dendrite suppression mechanism: Prohibiting of dendrite formation during charging is a very critical issue. We have found that dendrite formation tends to be suppressed in the presence of Li/Mg dual-salt electrolyte. Based on the phenomenon, we conversely clarify/deduce the dendrite formation/ inhibition mechanism.

【Expected Research Achievements and Scientific Significance】

Focusing on the fact that two types of carriers of monovalent and multivalent ions can exert a positive concerted effect, we can produce a feature, which cannot be achieved only by a single carrier, and we want to create an innovative mechanism of storage battery carriers.

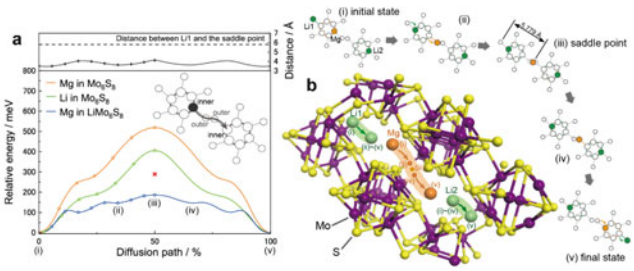

Figure 1 Lowering of diffusion barrier (left) and diffusion path of dual ions (right)

【Publications Relevant to the Project】

・H. Li, N. L. Okamoto, T. Hatakeyama, Y. Kumagai, F. Oba, T. Ichitsubo, Advanced Energy Materials, 1801475 (2018).
・H. Li, T. Ichitsubo, S. Yagi, E. Matsubara, Journal of Materials Chemistry A5, 3534 (2017).
・T. Ichitsubo, S. Okamoto, T. Kawaguchi, Y. Kumagai, F. Oba, S. Yagi, N. Goto, T. Doi, E. Matsubara, Journal of Materials Chemistry A3, 10188 (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 152,800 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Evolution of Attosecond Science by Next-generation Ultrashort-pulse Lasers

Jiro Itatani
(The University of Tokyo, the Institute for Solid State Physics, Associate Professor)

Research Project Number : 18H05250 Researcher Number : 50321724
Keyword : Attosecond science, Soft-X-ray spectroscopy, Ultrashort-pulse laser, Frequency conversion

【Purpose and Background of the Research】

The advancement of Ti:sapphire lasers in the past two decades has realized the generation of attosecond pulses, and opened a new field called "attosecond science." However, the limitations of Ti:sapphire lasers such as fixed laser wavelength and thermally-limited output power, is becoming a barrier to make further progress of attosecond science. In this project, we will develop intense ultrashort-pulse light sources of new generation, which consist of optical parametric chirped pulse amplifiers (OPCPAs) pumped by a high-average-power Yb-based solid-state laser. These novel light sources will transform attosecond science from the stage of proof-of-principle to a new optical technology that is applicable to a broad range of materials science. We aim to realize attosecond sources that cover vacuum ultraviolet (VUV), extreme ultraviolet (XUV), and soft-X-ray (SX) regions, with sufficient photon flux for ultrafast spectroscopy. We will also develop an attosecond beamline for advanced attosecond measurements.

【Research Methods】

There are two important scaling laws in attosecond pulse generation. With λ as a drive laser's wavelength, the cut-off photon energy of high harmonics is proportional to λ^2, while the conversion efficiency is proportional to $\lambda^{-(5\text{-}6)}$. Because of this trade-off, we will develop three OPCPA systems that are operated at different wavelength to cover the VUV, XUV, and SX regions. Advantages of the OPCPA over Ti:sapphire lasers are that (i) selection of nonlinear crystals and phase matching conditions allow us to design an ultrabroad parametric gain in various wavelength, and (ii) transparent nonlinear crystals are used as gain media that are free from thermal problems. We will also develop high-average-power Yb-based solid-stage lasers as a pump source for the OPCPAs. An attosecond beamline will also be developed to use high-photon-flux attosecond pulses for various advanced spectroscopy and imaging as shown in Fig. 1.

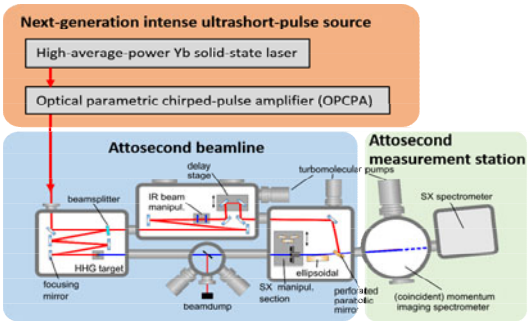

Figure 1 Schematic of an attosecond sources and an ultrafast measurement system.

【Expected Research Achievements and Scientific Significance】

We expect a significant increase of photon flux of attosecond pulses in VUV, XUV, and SX regions, which will enable a wide range of ultrafast spectroscopy of solids on the attosecond time scale. This will give us an opportunity to merge attosecond science and materials science, which leads to a new framework to understand the dynamics of non-equilibrium or highly-excited states of matters

【Publications Relevant to the Project】

N. Saito, N. Ishii, T. Kanai, S. Watanabe, and J. Itatani, "Attosecond streaking measurement of extreme ultraviolet pulses using a long-wavelength electric field," Scientific Reports, 6:35594, 1-5 (2016).
N. Ishii, K. Kaneshima, K. Kitano, T. Kanai, S. Watanabe, and J. Itatani, "Carrier-envelope phase-dependent high harmonic generation in the water window using few-cycle infrared pulses," Nature Commun. 5:3331, 1-6 (2014).

【Term of Project】 FY2018-2022

【Budget Allocation】 150,300 Thousand Yen

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Title of Project : Low temperature ammonia synthesis by heterogeneous catalysts enhancing electron-donating power

Michikazu Hara
(Tokyo Institute of Technology, Institute of Innovative Research, Professor)

Research Project Number : 18H05251 Researcher Number : 70272713
Keyword : Heterogeneous catalyst, Ammonia synthesis

【Purpose and Background of the Research】

The mass production of ammonia by so-called "Haber-Bosh process" using iron-based catalysts has supported the increase in human population and modern civilization for over 100 years. Because ammonia synthetic reaction is an exothermic reaction, increase in reaction temperature immediately decreases ammonia yield. In fact, the maximum ammonia yield at 400 °C cannot transcend 40% even under a high pressure of 20 MPa. For this reason, commercial ammonia production process using iron-based catalysts with high working temperatures over 400 °C requires compression to tens-a few tens MPa in order to achieve an ammonia yield of ca. 30%, causing large energy consumption and heavy manufacturing plant. Thus, further decrease in catalyst working temperature for increase in ammonia yield has been remaining as a challenging subject since ammonia production by Haber-Bosch process.

The aim of this study is to create a new heterogeneous catalytic system to give an ammonia yield over 80% under pressures below 5 MPa, i.e. a novel heterogeneous catalyst that works efficiently for ammonia synthesis below 150 °C, to overcome the above drawback in conventional ammonia production.

【Research Methods】

In this study, the desired catalyst is created by combining transition metal nanoparticles as active sites with a family of strong electron-donating materials that have both low work functions and stability under ammonia synthetic conditions via the followings.

1. The optimal combination of transition metal nanoparticles with the strong electron-donating materials as supports is found by examining ammonia synthetic activities for transition metal nanoparticles-deposited electron-donating materials.
2. The electron-donating capability of the selected electron-donating material is remarkably enhanced though several methods.
3. The catalyst consisting of transition metal nanoparticles and support enhancing electron-donating capability is examined through ammonia synthesis below 150 °C and 5 MPa to find the working principles for further efficient catalysts.

【Expected Research Achievements and Scientific Significance】

While "*Wind to Ammonia*"(Figure 1), on-site ammonia production using H_2 form wind power station, is attracting public attention as a sustainable ammonia production without using fossil resources, this is difficult to realize because conventional Haber-Bosch process consumes too much energy. This study to decrease energy consumption for ammonia synthesis can enable sustainable ammonia production through "Wind to Ammonia".

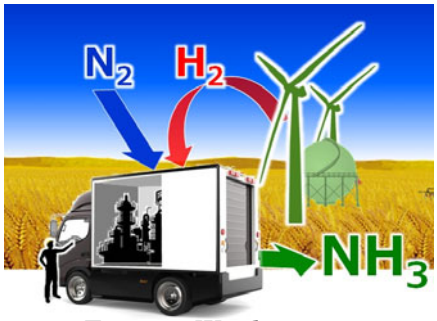

Figure 1 Wind to ammonia

【Publications Relevant to the Project】

・Komanoya, T; Kinemura, T; Kita, Y; Kamata, K; Hara, M*, "Electronic Effect of Ruthenium Nanoparticles on Efficient Reductive Amination of Carbonyl Compounds", *J. Am. Chem. Soc.*, **139**, 11493–11499, 2017.
・Hara, M*; Kitano, M; Hosono, H*, "Ru-Loaded C12A7:e⁻ Electride as a Catalyst for Ammonia Synthesis", *ACS Catalysis,* **7**, 2312-2324, 2017.

【Term of Project】 FY2018-2022

【Budget Allocation】 146,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.msl.titech.ac.jp/~hara
mhara@mas.titech.ac.jp.

Title of Project : Creation of platform for the next generation synchrotron radiation microspectroscopy by multi-dimensional X-ray ptychography

Yukio Takahashi
(Osaka University, Graduate School of Engineering, Associate Professor)

Research Project Number : 18H05253 Researcher Number : 00415217
Keyword : Synchrotron radiation, X-ray ptychography, Phase retrieval, X-ray absorption spectroscopy

【Purpose and Background of the Research】

Many practical materials are heterogeneous complex systems with domain structures from nanometer to sub-micrometer scale. Therefore, it is important to understand correlation between the fine structures and the function at nano-meso scale when we design and develop new functional materials.

So far, we have developed high-resolution and high-sensitivity X-ray ptychography that is nano structural imaging method based on the synchrotron coherent X-ray diffraction and phase retrieval calculation. Recently, we have demonstrated ptychographic-XAFS method which can visualize both the structure and chemical state of bulk materials at the nanoscale.

In this study, we will improve ptychographic-XAFS method, and then apply to correlation analysis of the fine structures and the function of various functional materials. Finally, we will create the platform for the next generation synchrotron radiation microspectroscopy.

【Research Methods】

We dramatically reduce the measurement time of ptychographic-XAFS method using X-ray optics approach and information technology approach. We establish multi-dimensional X-ray ptychography, in which ptychographic-XAFS method is extended to three-dimensional space by combining with computed tomography. We perform the correlation analysis of the fine structures and the function of functional materials, such as catalyst materials, polymeric materials, and magnetic materials.

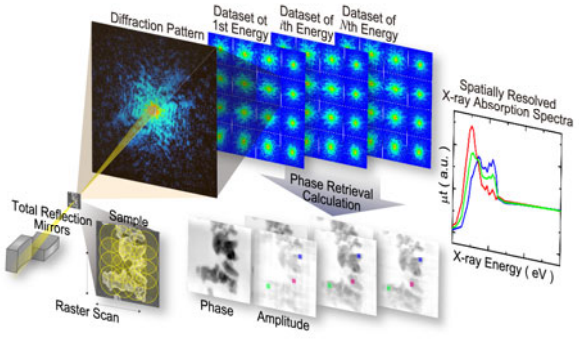

Figure 1 Representation of ptychographic-XAFS method.

【Expected Research Achievements and Scientific Significance】

Currently, TEM-EELS is widely used as a main tool for microspectroscopy. However, it is difficult to observe thick samples more than a few tens nanometer in thickness by TEM-EELS. On the other hand, multi-dimensional X-ray ptychography can observe the thick samples at ten nanometer resolution, and hence can pioneer the frontier of science of correlation between the structure and the function of heterogeneous complex systems.

The next generation synchrotron facilities provide us high-intense coherent X-rays. By utilizing the platform in the next generation synchrotron facilities, the design and development of new functional materials will be facilitated.

【Publications Relevant to the Project】

・A. Suzuki, K. Shimomura, M. Hirose, N. Burdet, and Y. Takahashi, "Dark-field X-ray ptychography: Towards high-resolution imaging of thick and unstained biological specimens", Scientific Reports 6, 35060 (2016).
・M. Hirose, K. Shimomura, N. Burdet, and Y. Takahashi, "Use of Kramers-Kronig relation in phase retrieval calculation in X-ray spectro-ptychography", Optics Express 25, 8593-8603 (2017).
・M. Hirose, N. Ishiguro, K. Shimomura, N. Burdet, H. Matsui, M. Tada, and Y. Takahashi, "Visualization of heterogeneous oxygen storage behavior in platinum-supported cerium-zirconium oxide three-way catalyst particles by hard X-ray spectro-ptychography", Angewandte Chemie International Edition 130, 1490-1495 (2018).

【Term of Project】 FY2018-2022

【Budget Allocation】 136,400 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : "Materials Science of Anisotropy" for induction of bone tissue anisotropy

Takayoshi Nakano
(Osaka University, Graduate School of Engineering, Professor)

Research Project Number : 18H05254 Researcher Number : 30243182
Keyword : biofunctional materials, bone anisotropy

【Purpose and Background of the Research】

Biological apatite crystallizes in an anisotropic hexagonal crystal system, which governs the mechanical function of bone tissue. The apatite orientation varies depending on the bone anatomical portion, which corresponds to the *in vivo* stress distribution (Figure 1).

In this project, we raise a fundamental and core question, "what makes anisotropy in bone tissue?" and try to answer it by an interdisciplinary approach merging "Materials Science" and "Bone Biology". We apply two identical strategies; (1) elucidation of mechanisms for spontaneous organization of bone anisotropy (direct approach) and (2) development of anisotropic bone implant using additive manufacturing (indirect approach).

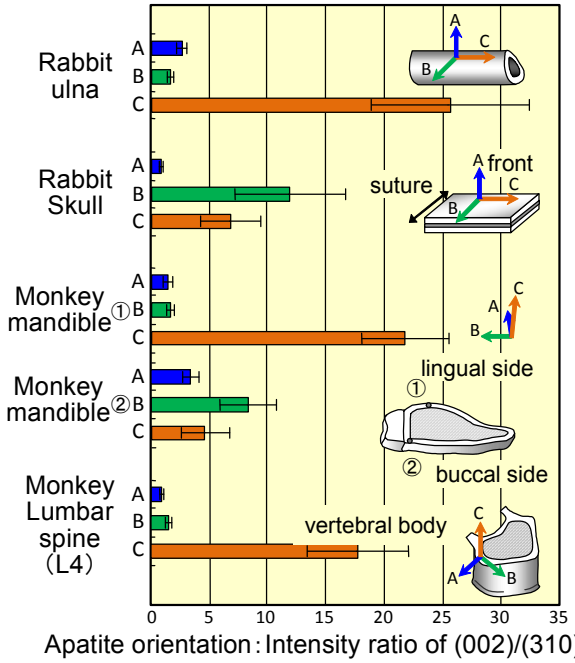

Figure 1 Apatite orientation depending on the bone anatomical portion

【Research Methods】

(1) Spontaneous generation process of anisotropy in biological system

Unveiling the biological mechanisms underlying the endogenous regulation of bone anisotropy mediated by cellular signaling.

(2) Construction of novel biomaterials which realize the anisotropic bone regeneration

Elucidation and control of regulatory mechanisms of anisotropic atomic arrangements in metal additive manufacturing for novel implants with biocompatible mechanical performances.

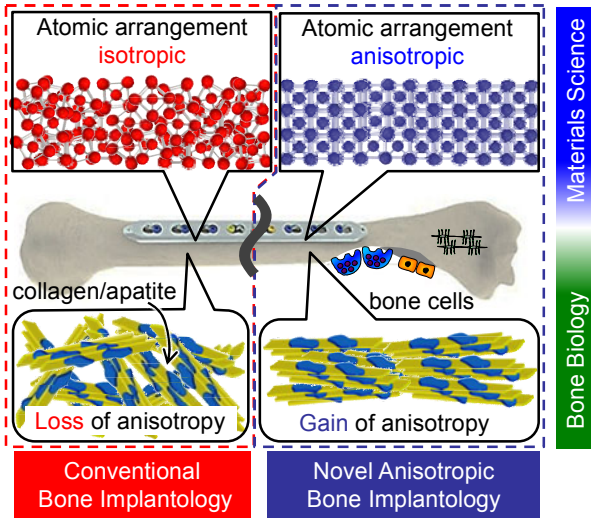

Figure 2 Development of a novel anisotropic bone implantology by merging "Materials Science" and "Bone Biology"

【Expected Research Achievements and Scientific Significance】

An interdisciplinary approach for unexplored mechanisms underlying the expression of "anisotropy" in bone tissue will pioneer a new scientific field, "Materials Science of Anisotropy".

【Publications Relevant to the Project】

・T. Ishimoto, K. Hagihara, T. Nakano *et al.*, *Scripta Materialia*, 132 (2017) pp. 34—38.
・T. Ishimoto, T. Nakano *et al.*, *Bone*, 103 (2017) pp. 216—223.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.mat.eng.osaka-u.ac.jp/msp6/nakano/
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Title of Project : Dynamics of Composite Electrodes in All-Solid-State Ionics Devices

Masahiro Tatsumisago
(Osaka Prefecture University, Graduate School of Engineering, Professor)

Research Project Number : 18H05255 Researcher Number : 50137238
Keyword : Composite electrode, Ionic conductor, Solid interface, Mechanical properties

【Purpose and Background of the Research】

All-solid-state ionics devices are attracting attention. Among them, the inorganic solid electrolyte-type all-solid-state batteries are the ultimate energy storage device having high safety, high energy density, high output and long life. Beginning with the commercialization of all-solid-state batteries coming in the near future, the arrival of all-solid-state ionics device era such as all-solid-state capacitors and all-solid-state air batteries is predicted. With respect to the construction of the solid-solid interface, which is a problem unique to all-solid-state ionics devices, there are many problems that have not yet been dissolved. We have found "a phenomenon of room temperature pressure sintering" so far and succeeded in constructing a favorable solid-solid interface. On the other hand, there are almost no academic approaches to various problems associated with mechanical phenomena occurring during device operation despite its high importance. Currently, it is only an understanding of phenomena caused by substance alone such as volume change of the electrode active material itself, and the essence of dynamics in the entire electrode composite is not understood at all.

In this research project, we aim to establish an academic foundation on the solid interface, which is a common problem of all-solid-state ionics devices, such as clarification of tasks related to composite electrode dynamics and suggesting solutions from the viewpoint of materials research.

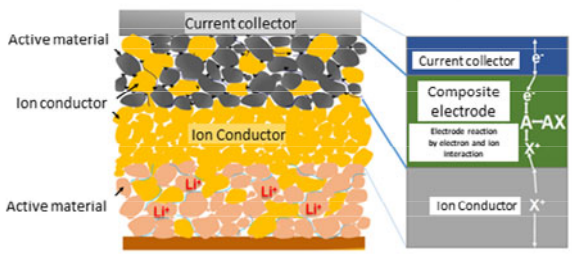

Fig. 1 Conceptual diagram of all-solid ionic device and the composite electrode.

【Research Methods】

We engage with the development of a method for quantifying the relationship between the structure and the electrical properties for the composite electrode, and the construction of a foundation for the properties of elastic and plastic regions of the composite electrode. Furthermore, we aim to create rubber elastic ionics materials and self-healing solid interfaces by plastic ionics materials. Mobile ions are not limited to lithium ion, but also sodium ion and the other ions. Also, we do comprehensively conduct research that contributes to solving common problems of electrode composites of all-solid-state devices, without limiting material types.

【Expected Research Achievements and Scientific Significance】

We are aiming to establish the foundation for "the construction and maintenance of the solid-solid interface" which is a common problem of all-solid-state ionics devices. These research on composite electrodes are an unexplored research field and thus the knowledge obtained here is extremely useful for a wide range of disciplines of engineering and other fields including material engineering and electrochemistry.

【Publications Relevant to the Project】

・A. Sakuda, A. Hayashi, M. Tatsumisago, “Sulfide Solid Electrolyte with Favorable Mechanical Property for All-Solid-State Lithium Battery”, *Sci. Rep.*, **3**-2261, 1-5 (2013).
・ A. Hayashi, A. Sakuda, M. Tatsumisago, “Development of Sulfide Solid Electrolytes and Interface Formation Processes for Bulk-Type All-Solid-State Li and Na Batteries”, *Front. Ener. Res.*, **4**:25, 1-13 (2016).

【Term of Project】 FY2018-2022

【Budget Allocation】 143,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www2.chem.osakafu-u.ac.jp/ohka/ohka2/english/index.html

Title of Project : Clarification of innovative deformation mechanism in harmonic structure materials and creation of design principle for structure materials for next generation

Kei Ameyama
(Ritsumeikan University, College of Science and Engineering, Professor)

Research Project Number : 18H05256 Researcher Number : 10184243
Keyword : Microstructure control, Heterogeneous structure, Strength, Ductility

【Purpose and Background of the Research】

Over many years, ultra-fine grained (UFG) metals have been proved to be attractive structural materials because of superior strength, especially when compared to their coarse-grained (CG) counterparts. However, the downside of homogeneous UFG materials is typically in a low elongation because of the plastic instability in the early stage of deformation. Therefore, fabrication of materials with superior combinations of high strength and high elongation remains a hot issue in material engineering.

The Harmonic Structure (HS) design can be a candidate materials design, which combines high strength with high ductility at the same time. Fig.1 demonstrates a concept of the HS design. As opposed to a "Homogeneous-UFG" material, "HS" material has a unique heterogeneous "Three-dimensionally (3D) Gradient Microstructure" wherein the UFG areas form an interconnected three-dimensional network surrounding CG regions, and CG and UFG areas are periodically arranged in all the directions.

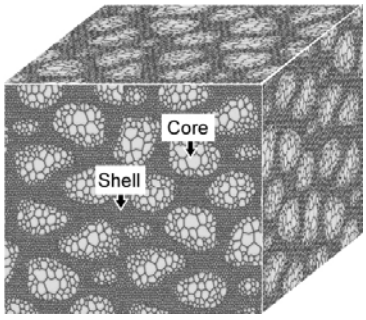

Fig.1 Concept of the HS Design

The HS materials demonstrate various anomalous deformation behaviors, such as "preferential recrystallization", "preferential stress induced transformation", and so on. Therefore, the purpose of the present research project is to reveal these unique deformation behaviors, and to create an innovative structure metallic materials design concept.

【Research Methods】

The first step of the research is to develop efficient process to fabricate the HS materials via several severe plastic deformation powder metallurgy processes. The HS materials are provided to deformation behavior analysis not only by an in-situ SEM deformation analysis facilities but also the Spring-8 synchrotron facility. Simulation techniques such as MD and FEM modellings are also applied to clarify deformation mechanism from the atomic scale.

【Expected Research Achievements and Scientific Significance】

By this research project, we can expect to solve the strength-ductility paradox. Understanding of the micro- and macro-scale deformation mechanisms will be the guide to create innovative structure materials. From the engineering point of view, the HS materials can be fabricated by combination of the classical industrial methods based on the powder metallurgy processes. It is worth to note that this research project will be very useful in the practical applications.

Furthermore, the young researchers as well as students expected to be grown through the international research collaborations in this research project.

【Publications Relevant to the Project】

S.K.Vajpai, M.Ota, Z.Zhang, K.Ameyama, *Three-Dimensionally Gradient Harmonic Structure Design: An Integrated Approach for High Performance Structural Materials*, Materials Research Letters, 4, 191-197, 2016.

J.Li, J.Liu, G.Dirras, K.Ameyama, F.Cazes, M.Ota, *A three-dimensional multi-scale polycrystalline plasticity model coupled with damage for pure Ti with harmonic structure design*, Int. J. Plasticity, 100, 192-207, 2018.

【Term of Project】 FY2018-2022

【Budget Allocation】 155,000 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Scanning tunneling microscopy for the development of ultimate nano-optics

Yousoo Kim
(RIKEN, Cluster for Pioneering Research, Chief Scientist)

Research Project Number : 18H05257 Researcher Number : 50373296
Keyword : Near-field light, Scanning tunneling microscope, Single molecule, Energy transfer/conversion

【Purpose and Background of the Research】

The interaction between light and matter is the origin of various "functions" such as color, luminescence, photochemical reaction, photoelectric conversion, etc.

When irradiated on a metal nanoscale structure, light can be collected in a tiny region of several nm which far exceeds the diffraction limit (several 100 nm) of light. We have studied spectroscopic measurements and photochemical reactions at the single-molecule level by using extremely small light (near-field light) localized between a metal probe of a scanning tunneling microscope (STM) and a metal substrate. However, the frequency and polarized state of the near-field light used so far have been extremely limited. That is mainly because that only the electric field component has been examined in the limited frequency range such as visible to near infrared in the linear response range.

This study aims at realizing near-field photochemistry and developing single-molecule spectroscopic measurement based on the interaction between the near-filed light at the STM tip and various quantum states of a target molecule.

【Research Methods】

For further development of near-field optical science, it is necessary to understand the near-field light itself more from the basic scientific point of view and to elucidate the interaction with the substance. However, in order to examine the near-field light itself precisely, it is enavitable to use a microscope having a spatial resolution of an atomic scale (~0.1 nm) which is sufficiently smaller than the size of the near-field light of several nm. Therefore, in this research, we precisely control the frequency and polarization state of the near-field light induced just under the STM probe, by changing the irradiating light variously. In addition, we clarify the interaction between near-field light and matter by conducting high-precision measurement and theoretical analysis using the quantum state of a single molecule as a probe in a system defined at the atomic level.

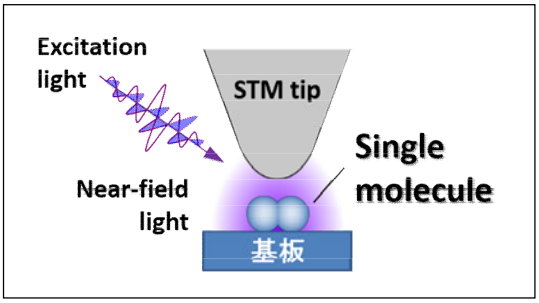

Figure 1 A schematic of creation of near-field light and its interaction with a single molecule

【Expected Research Achievements and Scientific Significance】

The detailed studies of the interaction between the near-field light and the matters will provide the establishment of the principle which governs the elementary process in the near-field optical microscope, near-field photochemical reaction, enhanced Raman scattering spectroscopy, etc.

【Publications Relevant to the Project】

・E. Kazuma, J. Jung, H. Ueba, M. Trenary, Y. Kim, “Real-space and real-time observation of a plasmon-induced chemical reaction of a single molecule” Science 360 (2018) 521.

・H. Imada, K. Miwa, M. Imai-Imada, S. Kawahara, K. Kimura and Y. Kim, “Single molecule investigation of energy dynamics in a coupled plasmon-exciton system” Phys. Rev. Lett. 119 (2017) 013901.

・H. Imada, K. Miwa, M. Imai-Imada, S. Kawahara, K. Kimura and Y. Kim, “Real-space investigation of energy transfer in heterogeneous molecular dimer” Nature 538 (2016) 364.

【Term of Project】 FY2018-2022

【Budget Allocation】 150,600 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Quantum Standards and Ultimate Precision Measurements Based on Single Electrons

Akira Fujiwara
(NTT Basic Research Laboratories, Physical Science Laboratory, Senior Distinguished Scientist)

Research Project Number : 18H05258 Researcher Number : 70393759
Keyword : single electron, quantum metrology triangle, quantum Hall, quantum electrical standards

【Purpose and Background of the Research】

One by one transfer and detection of electrons based on the single-electron charging effect in nanostructures enable us to build ultimate electronic devices such as quantum current standards and high sensitivity sensors, which will be applicable to ultimate precession measurements. This project is dedicated to the development of high speed single-electron transfer and detection devices, high-resistance quantum Hall arrays and current multiplication devices for high-accuracy current measurements. We aim at realizing the quantum metrology triangle (QMT) (Fig. 1), which is an experiment for the consistency check of three quantum electrical standards, with the best accuracy in the world.

【Research Methods】

In the 5 years project, NTT, AIST, and UEC will develop component devices and measurement techniques and combine them to perform high-accuracy QMT experiments cooperatively.

NTT will develop sub-10-GHz clocked silicon single-electron devices, which are key devices for quantum current standards generating a high (nanoampere level) current. Electron dynamics and error mechanism related to the single-electron transfer are intensively investigated to realize a high precision current source.

In order to convert the generated current to a voltage comparable to the Josephson voltage standard, AIST will develop 10-MΩ quantum Hall array resistance standards. Towards the final goal of QMT experiments, AIST will build a unified measurement system in a refrigerator including all quantum electrical standards (Fig. 1).

UEC will develop quantum current mirrors for precise current multiplication based on coupled arrays of Josephson tunnel junction. A novel scheme of single-electron detection in a sub-10-GHz regime is also studied utilizing single magnetic flux quantum (SFQ) circuits, which will be applied to absolute evaluation of the accuracy of single-electron current standards.

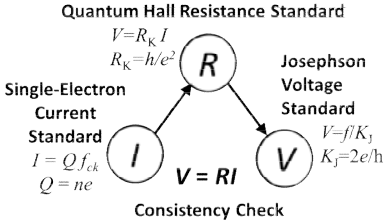


Fig. 1 Quantum metrology triangle (QMT)

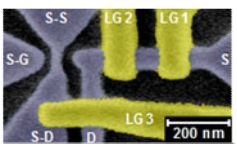


Fig. 2 Silicon single-electron devices

【Expected Research Achievements and Scientific Significance】

QMT has been perused for decades towards consistency check of the fundamental constants of nature such as the Planck constant and the elementary charge. Scientific impact of the QMT realization with the world-best accuracy will be significantly high. Furthermore, developed devices and techniques in the project are expected to lead to portable standards/calibration systems, real-time sensors for chemical and biological applications, and ultimate precision measurement apparatuses, which are all beneficial in various engineering and industrial fields.

【Publications Relevant to the Project】

・G. Yamahata, K. Nishiguchi, and A. Fujiwara, Gigahertz single-trap electron pumps in silicon, Nat. Commun. **5**, 5038 (2014).
・G. Yamahata et al., Gigahertz single-electron pumping in silicon with an accuracy better than 9.2 parts in 107, Appl. Phys. Lett. **109**, 013101 (2016).
・N. Kaneko, Review of Quantum Electrical Standards and Benefits and Effects of the Implementation of the 'Revised SI', IEEJ Trans. **12** 627 (2017).

【Term of Project】 FY2018-2022

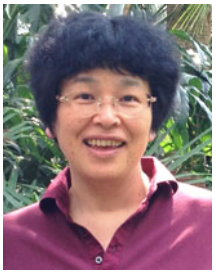
【Budget Allocation】 151,400 Thousand Yen

【Homepage Address and Other Contact Information】

NTT : http://www.brl.ntt.co.jp/people/afuji/
http://www.brl.ntt.co.jp/e/group_004/group_004.html
AIST :
https:// unit.aist.go.jp/ripm/qelec-std/
UEC : http://inaho.pc.uec.ac.jp/

【Grant-in-Aid for Scientific Research (S)】

Broad Section E



Title of Project : Catalytic Bond-Cleavage Reactions toward Utilization of Renewable Resources

Kyoko Nozaki
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05259 Researcher Number : 60222197
Keyword : Renewable resources, Catalyst, Reduction, Bond-cleavage, Metal–ligand cooperative effect

【Purpose and Background of the Research】

The chemical industry has developed a method of converting exhaustible fossil resources into various useful substances. Synthetic chemistry is the major stream, that assembles simple constituents such as C2~5 fractions and BTX (benzene · toluene · xylenes) given by cracking naphtha obtained from petroleum. Also, most of the conventional chemical processes are oxidation of these highly reduced carbon compounds.

On the other hand, different methodology will be needed for utilization of biomass such as lignin and grease, which are renewable carbon resources. Since the carbon atoms in renewables are often highly oxidized, it is necessary to reduce the carbon atoms for the effective utilization of them. Furthermore, as renewable resources are often mixtures of complex compounds, "decomposition chemistry" need to be considered in order to convert the macromolecules into small molecules for easy handling.

This research aims to develop catalytic bond-cleavage reactions, which are necessary when considering effective use of renewable carbon resources.

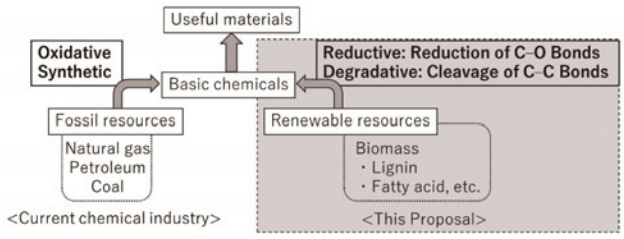


Figure 1. The purpose of this research.

【Research Methods】

1. Reductive cleavage of C–O bonds in the reduction of highly oxidized resources: Especially toward the synthesis of aromatic hydrocarbons and their analogues from lignin, we aim to develop selective hydrogenolysis catalyst of C–O bond in phenol and aryl methyl ether which are commonly found in the partial structure of lignin.

2. Cleavage of C–C bonds contributing to decomposition of complex structures: Toward utilization of aliphatic carboxylic acids, we focus on the decarboxylation–dehydrogenation of aliphatic carboxylic acids. The dehydrogenation–decarbonylation from aliphatic alcohols and aldehydes will be also examined. In addition, the dehydrogenation–retro-aldol reaction of a 1,3-diol structure, a partial structure of lignin, will be also investigated. These findings will pave the avenue of basic science toward the production of basic chemicals from renewable resources.

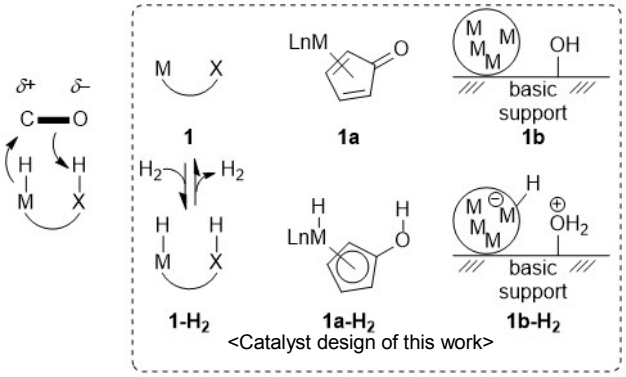


Figure 2. Approach of this study.

【Expected Research Achievements and Scientific Significance】

The concept of catalytic design in homogeneous catalysis will be expanded to heterogeneous systems. The success of this research opens up a new field of "decomposition chemistry".

【Publications Relevant to the Project】

・Direct and Selective Hydrogenolysis of Arenols and Aryl Methyl Ethers. S. Kusumoto, K. Nozaki *Nat. Commun.*, **2015**, *6*, 6296.
・The Retro-Hydroformylation Reaction. S. Kusumoto, T. Tatsuki, K. Nozaki *Angew. Chem. Int. Ed.* **2015**, *54*, 8458.

【Term of Project】

FY2018-2022

【Budget Allocation】

147,900 Thousand Yen

【Homepage Address and Other Contact Information】

http://park.itc.u-tokyo.ac.jp/nozakilab/indexE.html

Title of Project : Multiscale Interfacial Molecular Science for Innovative Functional Materials

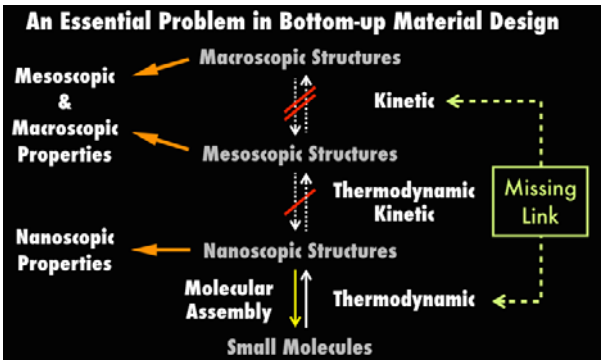
Takuzo Aida
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05260 Researcher Number : 00167769
Keyword : Supramolecular Chemistry, Hybrid Materials, Physical Perturbations, Surface/Interface

【Purpose and Background of the Research】

A remarkable progress in supramolecular chemistry in the last two decades now allows us to design and tailor a variety of desired nanostructures by optimizing a thermodynamic control. However, there still remains an essential missing link between molecular/nano structures and those with meso/macroscopic size regimes. This is mainly because the assembling events from "nanoscale size regimes" toward "upper hierarchical levels" suffer from an irreversible interference by numerous kinetic traps, leading to the formation of ill-defined macroscopic structures. On the other hand, in living system, many biological events rely on certain macroscopic structural anisotropies of biomaterials. Those anisotropic structures are constructed under physical perturbations such as electrical potentials, ion/fluid fluxes, osmotic pressures, and sheer forces.

Having a lesson from biological assembling events, we are taking up the challenge of filling the above-mentioned "missing link" by applying physical perturbations to our highly reputed assembled motifs.



【Research Methods】

In this project, we will mainly focus attention on utilization of three chemical motifs (1)–(3), all of which require a certain structural anisotropy up to a macroscopic length scale for their practical applications. Motif (1) is the first self-repairable polymer glass. Motif (2) is ionic liquid-based polyelectrolites showing extra-large capacitance. Motif (3) is a non-spherical polyelectolyte such as titanate nanosheets with orientaion properties in a magnetic field.

【Expected Research Achievements and Scientific Significance】

This project will cause a big paradigm shift in industrial technologies as well as basic sciences. (1) Development of self-repairing polymer glass is important for application to various types of self-repairing plastics, leading to a major step toward achieving sustainable development goals (SDGs). (2) Large capacitance of polyelectrolytes leads to practical applications as large-capacity electricity storage devices. (3) Anomalous behaviors of non-spherical polyelectrolytes are utilized for the development of "anisotropic colloid science", which will open up a new field of material science and will pave the way for a full-fledged artificial muscles and cartilages. We apply a variety of physical perturbations to control kinetic events of the assembly of large-dimension nanostructures and achieve structural anisotropies.

【Publications Relevant to the Project】

・Y. Yanagisawa *et al.* Mechanically robust, readily repairable polymers via tailored noncovalent cross-linking, *Science* **359**, 72–76 (2018).
・M. Matsumoto *et al.* Ultrahigh-throughput exfoliation of graphite into pristine 'single-layer' graphene using microwaves and molecularly engineered ionic liquids, *Nature Chem.* **7**, 730–736 (2015).
・M. Liu *et al.* An anisotropic hydrogel with electrostatic repulsion between cofacially aligned nanosheets, *Nature* **517**, 68–72 (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://macro.chem.t.u-tokyo.ac.jp
aida@macro.t.u-tokyo.ac.jp

【Grant-in-Aid for Scientific Research (S)】

Broad Section E

Title of Project : Chemistry of Boron-Containing π-Electron Materials

Shigehiro Yamaguchi
(Nagoya University, Institute of Transformative Bio-Molecules, Professor)

Research Project Number : 18H05261 Researcher Number : 60260618
Keyword : boron, p-electron system, planarization, supramolecular polymer, radical

【Purpose and Background of the Research】

Introduction of boron atoms into π-conjugated skeleton produces π-electron materials with characteristic electronic structures. In particular, group 13 boron can impart electron-accepting character to a π-skeleton due to an empty p-orbital of boron. For instance, triphenylborane is isoelectronic with triphenylmethyl cation and doping of boron atoms into graphene imparts semiconducting properties. In general, however, boron-containing materials are unstable due to high Lewis acidity. Steric protection of the boron center is necessary for gaining sufficient stability.

With regard to this issue, we recently found that structural constraint in a planar fashion enables producing stable boron-containing π-electron systems despite the absence of steric protection. Based on this design principle, we have so far synthesized a series of planarized boron-containing π-electron materials and investigate their characteristic properties. This chemistry can be regarded as a model study of boron-doped graphenes. Beyond this perspective, herein we aim at producing unusual properties and functions by making best use of characteristic features of planarized boron π-skeleton (Fig. 1).

【Research Methods】

Planarization of triarylboranes gives rise to 1) electron-accepting properties through effective orbital interaction between the empty p-orbital of boron and π-skeleton, 2) high Lewis acidity due to the absence of steric congestion, and 3) π-stacking ability due to the planar structure. Exploiting these features, we will pursue unusual photophysical and electronic properties and achieve controlling the self-assembled structure through the formation of supramolecular polymers. For instance, we recently developed a boron-stabilized π-radicals, which showed ambipolar carrier transporting ability in single crystal FET. We will tackle on more unusual and superb radical materials based on this type of π-skeletons. Moreover, we will synthesize various types of attractive planar π-electron materials and supramolecular polymers.

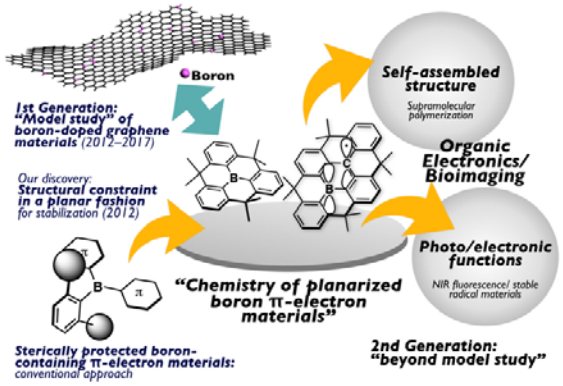


Fig. 1 Chemistry of planarized boron-containing π-electron materials

【Expected Research Achievements and Scientific Significance】

Understanding and exploitation of determinant factors of elements that govern materials functions are a fundamental issue of chemistry. Our approach in this project would contribute to progress not only in organoboron or main-group chemistry, but also in materials science, particularly organic electronics. Application to bioimaging would be also an important direction of this chemistry.

【Publications Relevant to the Project】

・T. Kushida, S. Shirai, N. Ando, T. Okamoto, H. Ishii, H. Matsui, M. Yamagishi, T. Uemura, J. Tsurumi, S. Watanabe, J. Takeya, S. Yamaguchi, *J. Am. Chem. Soc.*, **139**, 14336-14339 (2017).
・Z. Zhou, A. Wakamiya, T. Kushida, S. Yamaguchi, *J. Am. Chem. Soc.*, **134**, 4529-4532 (2012).

【Term of Project】

FY2018-2022

【Budget Allocation】

149,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://orgreact.chem.nagoya-u.ac.jp/olddocs/Home.html

Title of Project : Chemistry of Adaptable Space

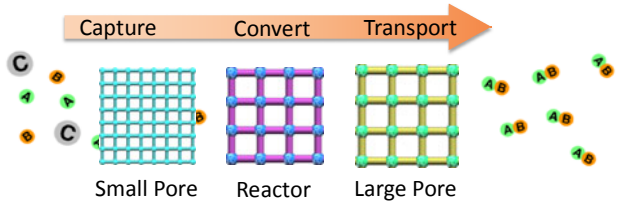
Susumu Kitagawa
(Kyoto University, Institute for Advanced Study, Institute for Integrated Cell-Material Sciences, Distinguished Professor)

Research Project Number : 18H05262 Researcher Number : 20140303
Keyword : Porous Coordination Polymer, Dynamic Function, Interface, Mass Transportation

【Purpose and Background of the Research】

Living organisms adapt themselves to various environmental changes. From chemistry standpoint, this spontaneous adaptation function is realized by the establishment of a "flow" that governs nano-level multiple functions such as transmitting molecular signals and transferring ions between inside and outside the cell membrane. In this research, we design a basic operation of living organisms such as reception, detection, transfer, conversion, etc. into porous materials by encoding those functional essences in dynamic nanospaces, to establish a new scientific paradigm of porous materials that respond to various environmental changes and signals.

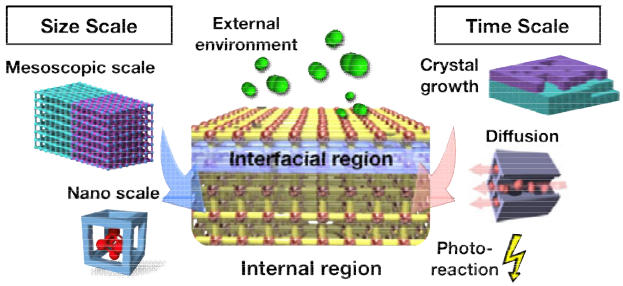
Specifically, Porous Coordination Polymers (PCP, Metal–Organic Framework: MOF) is mainly used as a nanospace platform for developing targeted functions. Chemistry for fusing different PCP crystals will be studied and developed to establish fundamental technologies for creating flows that amplify and propagate molecular signals. This represents the system and theory in "Chemistry of Adaptable Space" that we propose.



【Research Methods】

An important issue in creating the adaptive space is the development of an organic fusion method of PCP crystals. Designs of crystallite size, electric charge and molecular motions in nanopores as well as understanding interface structures of PCP crystals are essential foundation of this research.

For the fusion of PCP crystals and nanopore domains, we apply epitaxial growth method[1] and synthesis of molten PCP[2] that we have developed. Synthesis of asymmetric PCP single crystals having different pore diameters and static potentials, etc., will be targeted to realize the flow that propagates and transmits stimuli and signals.



【Expected Research Achievements and Scientific Significance】

Following outcomes are anticipated: (1) Development of new materials that separate, capture and convert in response to concentrations of component gas species such as CO_2, CO, CH_4, O_2, etc. in exhaust gas, flue gas, and biogas, etc. (2) Applications to such as membranes that regulate ionic species such as Li^+, Na^+, Ca^{2+}, and NH^{4+}, etc. and spontaneously control their conductivity in response to external environment. This research will lead to the creation of materials with synergistic molecule/information conversion function which cannot be obtained by individual function of a single substance.

【Publications Relevant to the Project】

1."Sequential Functionalization of Porous Coordination Polymer Crystals." Hirai, K.; Furukawa, S.; Kondo, M.; Uehara, H.; Sakata, O.; Kitagawa, S. *Angew. Chem. Int. Edit.* **2011**, *50*, 8057–8061.

2."Reversible Solid-to-Liquid Phase Transition of Coordination Polymer Crystals" Umeyama, D.; Horike, S.; Inukai, M.; Itakura, T.; Kitagawa, S. *J. Am. Chem. Soc.*, **2015**, *137*, 864–870.

【Term of Project】 FY2018-2022

【Budget Allocation】 149,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.kitagawa.icems.kyoto-u.ac.jp

Title of Project : Creative Research and Development of Incoherent Nonlinear Photoswitchable Molecules

Jiro Abe
(Aoyama Gakuin University, College of Science and Engineering, Professor)

Research Project Number : 18H05263 Researcher Number : 70211703
Keyword : Photochromism, Photochemistry, Nonlinear Optical response

【Purpose and Background of the Research】

Photochromic molecules, which can reversibly interconvert between stable and metastable isomers upon exposure to light, are key elements for the development of photo-responsive systems that offer promising perspectives in the materials and life sciences. However, traditional photochromic molecules require the use of high-energy UV light for isomerizing in at least one direction. The use of UV light comes with inherent limitations for a range of applications that arise from irreversible chemical damage and limited penetration depth in many materials. Moreover, background light causes an undesired photochromic reaction because a linear absorption of light would occur even for one photon irradiation.

Recently, we have developed novel fast photochromic molecules which involve the stepwise two-photon reaction. These photochromic molecules show unique nonlinear photo-response. Only the short-lived transient colored species are formed by illumination with weak light, whereas the excitation with high power CW light generates the long-lived transient colored species. Although high power pulse lasers were necessary to induce conventional simultaneous and stepwise two-photon absorption processes, the stepwise two-photon absorption process with the fast photochromic compound can be initiated by extremely weak continuous wave (CW) LEDs.

We will develop nonlinear visible-light responsive photochromic molecules that can work only under high-power CW light and exclude the influence of background light.

【Research Methods】

In this research project, we will focus on the development of the innovative photochromic molecules capable of visible-light excitation and wavelength selective excitation by combining the fast photochromism, the stepwise photochromism, and the stepwise photochromism via higher excited state. The first objective is to realize the nonlinear photochromic reaction upon the excitation with visible light between 400 and 600 nm, and the final goal is set to achieve the stepwise photochromic reaction with visible light longer than 650 nm or near infrared pulse light.

【Expected Research Achievements and Scientific Significance】

A reverse saturable absorber (RSA) is a material whose absorption coefficient would increase with increasing the excitation light intensity. On the other hand, a material whose absorption coefficient would decrease when the excitation light intensity increases is known as a saturable absorber (SA). Nonlinear photo-responsive photochromic molecules changing their color from colorless to colored (positive photochromism) upon high-power UV LED can be considered as RSAs. On the other hand, those changing their color from colored to colorless (negative photochromism) can be regarded as SAs. We expect the RSA and SA properties induced without the use of high power laser source can be applied to unique optical shutters and optical filters.

【Publications Relevant to the Project】

・Y. Kobayashi, T. Katayama, T. Yamane, K. Setoura, S. Ito, H. Miyasaka, J. Abe, “Stepwise two-photon induced fast photoswitching via electron transfer in higher excited states of photochromic imidazole dimer”, *J. Am. Chem. Soc.*, **138**, 5930-5938 (2016).
・K. Mutoh, Y. Nakagawa, A. Sakamoto, Y. Kobayashi, J. Abe, “Stepwise two-photon-gated photochemical reaction in photochromic [2.2]paracyclophane-bridged bis(imidazole dimer)”, *J. Am. Chem. Soc.*, **137**, 5674-5677, (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 149,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.chem.aoyama.ac.jp/Chem/ChemHP/phys3/top/abe.html

Title of Project : Clarification of Ubiquitous Proton Function in Photoreceptive Proteins by Quantum Molecular Dynamics Simulations

Hiromi Nakai
(Waseda University, Faculty of Science and Engineering, Professor)

Research Project Number : 18H05264 Researcher Number : 00243056
Keyword : Photoreceptive proteins, Quantum molecular dynamics, Ubiquitous protons, DC-DFTB-MD

【Purpose and Background of the Research】

Biological molecules possess the sophisticated mechanisms for achieving functions as a result of the long-time evolution. At the atomic level, protons ubiquitously exist in biological systems in various forms, and show heterogeneous dynamical behavior coupling with the electron-state changes and structural changes in the surrounding environment. The resulting proton transfers play a vital role in the mechanisms for achieving functions on life phenomena. Therefore, in order to elucidate the mechanisms for achieving functions in biological systems at the atomic level, it is important to correctly understand the dynamical behavior of ubiquitous protons.

In experimental studies, various structures of biological molecules have been determined from x-ray crystallography and cryo-electron microscopy. However, the positions and dynamical processes of protons have not been observed due to the limit of the temporal and spatial resolution. In theoretical studies, although chemical reactions have been analyzed with quantum molecular dynamics (QMD), the tractable number of atoms is limited to at most one thousand due to the high computational cost. Thus, elucidating the dynamical behavior of ubiquitous protons is significantly difficult.

In the present study, the microscopic mechanisms of life phenomena will be clarified using our original large-scale QMD.

【Research Methods】

Our original QMD, divide-and-conquer-type density-functional tight-binding molecular dynamics (DC-DFTB-MD), is further improved in combination with GPU accelerator. Extension of this method for excited states is also performed.

As an application to photoreceptive proteins, ubiquitous proton transfers in bacteriorhodopsin (BR), which has the function of light-driven proton pump, are analyzed. From DC-DFTB-MD of BR with lipid bilayer and water (Figure 1), multiple proton transfers on the photocycle are fully observed, and the microscopic origin of the unidirectional and active proton transport in BR resulting in light-energy conversion is elucidated.

In addition to BR, ion-transporting microbial rhodopsins and ATP synthase are targets of the present study. The microscopic mechanisms of various biological functions in these systems are clarified from the viewpoint of ubiquitous protons.

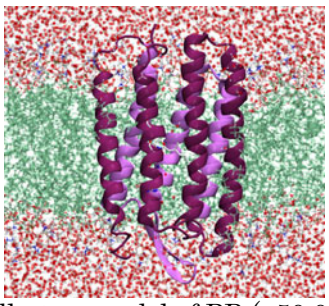


Figure 1. All-atom model of BR (~50,000 atoms).

【Expected Research Achievements and Scientific Significance】

Theoretical basis of revealing the dynamical behavior of ubiquitous protons in arbitrary biological systems is constructed. Moreover, it is expected that we can gain microscopic insights into the essence of life phenomena involving chemical reactions and develop the biological materials with high efficiency.

【Publications Relevant to the Project】

・"Three pillars for achieving quantum mechanical molecular dynamics simulations of huge systems: Divide-and-conquer, density functional tight-binding, and massively parallel computation" H. Nishizawa, Y. Nishimura, M. Kobayashi, S. Irle, and H. Nakai, *J. Comput. Chem.*, **37**, 1983 (2016).
・"Rigorous pKa Estimation of Amine Species Using Density-Functional Tight-Binding-Based Metadynamics Simulations" A. W. Sakti, Y. Nishimura, and H. Nakai, *J. Chem. Theory Comput.*, **14**, 351 (2018).

【Term of Project】 FY2018-2022

【Budget Allocation】 151,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.chem.waseda.ac.jp/nakai/
nakai@waseda.jp

【Grant-in-Aid for Scientific Research (S)】

Broad Section E

Title of Project : Exploring Interface Science by Concerted Use of Advanced Spectroscopy and Theory

Tahei Tahara
(RIKEN, Cluster for Pioneering Research, Chief Scientist)

Research Project Number : 18H05265 Researcher Number : 60217164
Keyword : Interface, Nonlinear Spectroscopy, Ultrafast, MD Simulation, Molecular Science

【Purpose and Background of the Research】

Although interfaces play crucial roles in many areas of science and technology, our understanding of interfacial phenomena is insufficient. In this research, researchers who have been developing new experimental and theoretical methodologies collaborate and promote research on liquid interfaces. We clarify static and dynamic processes at the interfaces and elucidate their mechanisms at the molecular level.

【Research Methods】

By using phase-controlled interface selective nonlinear spectroscopy and molecular dynamics simulation, we investigate liquid interfaces by focusing on the following three issues.

(1) Ultrafast interfacial vibrational dynamics

Elucidation of the ultrafast phenomena is the frontier of science. In particular, elucidation of ultrafast dynamics of the hydrogen bonding is essentially important. Ultrafast hydrogen-bond dynamics of bulk water has been intensively studied, but the dynamics at the interface is not elucidated. We investigate it by femtosecond time-resolved phase-controlled sum-frequency generation spectroscopy and its extension to two-dimensional spectroscopy.

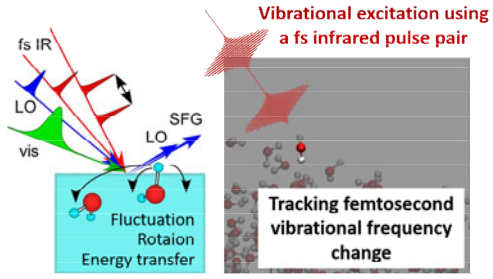


Figure 1 Ultrafast dynamics at liquid interfaces

(2) Structure of liquid interfaces and reactions

Reactions at the liquid interface are thought to be different from those in the solution, but it has not been clarified. We elucidate the structure of liquid interfaces and clarify their effects on the reactivity of interfacial molecules. Furthermore, we observe the interfacial reaction process by the time-resolved measurement directly.

(3) Buried interfaces and complex real interfaces

"Buried interfaces" such as solid/liquid interfaces are an unexplored area. We elucidate the properties of the buried interfaces at the molecular level, from oxide/water interfaces to complex interfaces that are widely utilized in the real world such as the electrode interface.

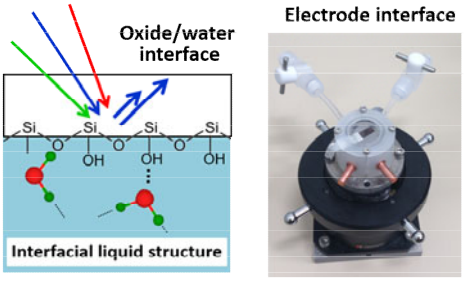


Figure 2 Buried interface and real complex interface

【Expected Research Achievements and Scientific Significance】

The outcomes of this research not only greatly advance interfacial science, but also provide solid basis to a wide range of science and technology including environmental chemistry and electrochemistry where interfacial phenomena play major roles.

【Publications Relevant to the Project】

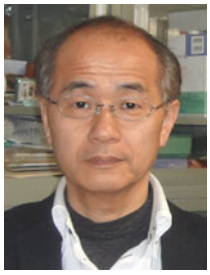
・ Nihonyanagi, S.; Yamaguchi, S.; Tahara, T. Ultrafast dynamics at water interfaces studied by vibrational sum-frequency generation. *Chem. Rev.* **2017**, *117*, 10665-10693.
・ Ishiyama, T.; Imamura, T.; Morita, A. Theoretical studies of structures and vibrational sum frequency generation spectra at aqueous interfaces. *Chem. Rev.* **2014**, *114*, 8447-8470.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,400 Thousand Yen

【Homepage Address and Other Contact Information】

https://spectroscopy.riken.jp/?lang=en
tahei@riken.jp



Title of Project : Development of basic technology of chemistry and biology for reducing damage by root parasitic weeds

Tadao Asami
(The University of Tokyo, Graduate School of Agricultural and Life Sciences, Professor)

Research Project Number : 18H05266 Researcher Number : 90231901
Keyword : root parasitic weeds, strigolactones, suicidal germination, inhibitor, receptor, biosynthesis

【Purpose and Background of the Research】

Strigolactones (SLs) are a plant hormone that regulates branching of plants. They also promote the germination of root parasitic plants that grow in the host plant's root, such as genus *Striga*. The root parasitic weeds infest cereals and non-cereals crops respectively, resulting 50-90% yield losses. Therefore, chemicals that regulate the functions of SLs will be very useful, so in this project we will try to develop several SL biosynthesis inhibitors, agonists and antagonists to reduce the damage by root parasitic weeds. Followings are important characters of chemicals: SL biosynthesis inhibitors must inhibit SL biosynthesis in host plants without morphological change of host plants, SL agonists must induce germination of root parasitic weeds without roots of host plants (suicidal germination) and antagonists must inhibit the perception of SLs in root parasitic weeds. To understand the mechanisms how these chemicals are perceived by their target proteins, we will also try to crystalize the complex of proteins and chemicals. As ethylene also induce suicidal germination, we will try to prepare ethylene agonists and antagonists, which will be used to facilitate the crystallization of ethylene receptors.

【Research Methods】

We have already reported a lead compound for SL biosynthesis inhibitor TIS103. In this project, we will carry out a structure-activity relationship study of TIS13 to discover more potent and specific SL biosynthesis inhibitor because TIS13 has a severe side effect at high concentrations. We will identify the target sites of the new potent inhibitors and prepare knockout mutants of the target proteins. We found that treatment of GAs also reduces the level of SLs. This means that GA can be used to protect plants from the attack of *Striga*. AC94377 and D67 are good candidates of GA agonists but their mode of binding to GA receptor is not clear. Here we will try to clarify 3D structures of complex between GA agonists and GA receptors, which will facilitate the design of new GA agonists.

To design suicidal germination inducers, we try to understand the mechanism of SL perception. At present two mechanisms, (A) and (B), are proposed as shown in Figure 1. We found receptor inhibitors that covalently bind to the catalytic site of SL receptors and inhibit the germination of *Striga* seeds induced by SLs. Among these covalent inhibitors, we found AGOL also covalently binds to catalytic site of SL receptors but shows agonistic activity. Investigation on the activation mechanism of SL signals by AGOL will make clear the mechanism of activation pathway (A). This research will facilitate the design of new suicidal germination inducers.

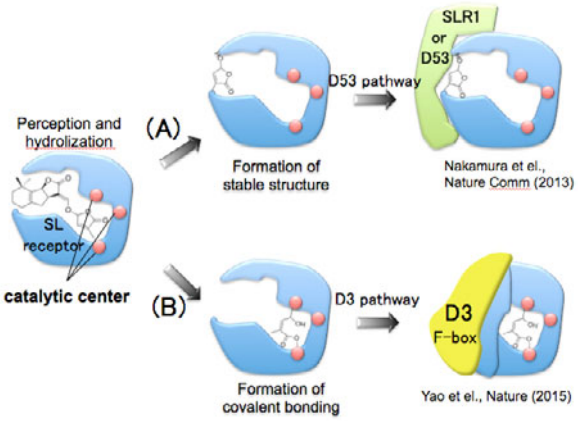


Figure 1. Perception of SL by SL receptor

【Expected Research Achievements and Scientific Significance】

- Practical use of developed chemicals in the infested fields
- Proposal of new mode of action of SLs

【Publications Relevant to the Project】

Nakamura H, et al., Molecular mechanism of strigolactone perception by DWARF14. ***Nature Comm***, **4**: 2613 (2013).
Zhou F et al., D14-SCFD3-dependent degradation of D53 regulates strigolactone signaling. ***Nature***, **504**: 406-410 (2013).

【Term of Project】 FY2018-2022

【Budget Allocation】 151,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://pgr.ch.a.u-tokyo.ac.jp/

【Grant-in-Aid for Scientific Research (S)】

Broad Section F

Title of Project : Identification of primer pheromones in mammals and elucidation of a neural basis for the pheromone action

Kazushige Touhara
(The University of Tokyo, Graduate School of Agricultural and Life Sciences, Professor)

Research Project Number : 18H05267 Researcher Number : 00280925
Keyword : Pheromone, olfaction, receptor, neural circuit, reproduction

【Purpose and Background of the Research】

Pheromones are categorized into two types; one that elicits specific behavior, calling a releaser pheromone, and another that causes physiological effects, calling a primer pheromone. Studies on a releaser pheromone have been much progressed at the level of molecule, receptor, and neural circuitry using insects and mice, whereas there are not many studies for mammals including human. In this study, we will identify primer pheromones in mice that induce synchronous estrus, accelerate puberty, or cause sexual suppression, and their receptors and neural circuits responsible for the effects. We will also look for primer pheromones in humans and identify a brain region involved in the physiology. The molecular and neural mechanisms underlying primer pheromone actions related to reproductive function will be revealed.

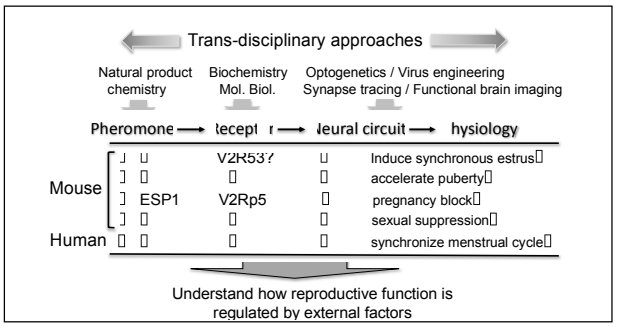


Figure Aims,

【Research Methods】

Regarding mouse primer pheromones, we will develop an *in vivo* Ca^{2+} imaging method using fiber photometry, purify active compound(s) from urine by HPLC, and determine the structure(s) based on GC-MS/LC-MS followed by chemical synthesis. We will reveal the receptors for the identified primer pheromone using a double in situ hybridization strategy from ~300 vomeronasal receptors. The neural circuitry underlying the pheromone action will be dissected by using virus technology and optogenetic and phamacogenetic approaches. To identify human pheromones, we will use non-invasive functional brain imaging techniques and measure autonomic nervous functions and endocrinological changes.

【Expected Research Achievements and Scientific Significance】

Mouse primer pheromones identified during '80 by Novotony group have been denied in 2011 by Stowers group. The human dormitory effect reported by McClintock in 1971 has not been characterized at the level of molecule. The only primer pheromone in mammals so far is a goat male pheromone identified by Murata et al. in 2014. Thus, revealing primer pheromones, their receptors, and responsible neural circuits gives a high impact in the field. Moreover, this will be the first molecular study on human pheromone. The approach is transdisciplinary in the field of chemistry-biology; from natural product chemistry, receptor signaling biology, to brain science. In practical senses, the expected results will become valuable information that helps various problems in reproductive functions in human and mammals.

【Publications Relevant to the Project】

・Hattori, T., Osakada, T., Masaoka, T., Oyama, R., Horio, N., Mogi, K., Nagasawa, M., Haga-Yamanaka, S., Touhara, K.* and Kikusui, T.* "Exocrine gland-secreting peptide 1 is a key chemosensory signal responsible for the Bruce effect in mice"
Current Biology 27, 3197-3201 (2017)
・Ishii, K., Osakada, T., Mori, H., Miyasaka, N., Yoshihara, Y., Miyamichi, K.*, and Touhara, K.* "A Labeled-Line Neural Circuit for Pheromone-Mediated Sexual Behaviors in Mice"
Neuron 95, 123-137 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 147,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://park.itc.u-tokyo.ac.jp/biological-chemistry/

Title of Project : Antiaging system of long-lived termite kings

Kenji Matsuura
(Kyoto University, Graduate School of Agriculture, Professor)

Research Project Number : 18H05268 Researcher Number : 40379821
Keyword : longevity, antiaging, termite, metabolome, social insects

【Purpose and Background of the Research】

Eusocial insects, such as ants, bees, wasps, and termites, are characterized by a system of caste division (reproductive vs. non-reproductive individuals), where the lifespan of queens (and kings in termites) can reach 100 times longer than the average lifespan of non-social insects. Recent our study revealed that kings of some termite species including *Reticulitermes speratus* have extremely long life span, which is comparable to human longevity, due to their unique reproductive system AQS (Asexual Queen Succession).

Generally, longevity negatively correlates with reproduction. Most animals show a gradual decline in reproduction with age. Nevertheless, termite kings are the most sexually active individuals and also the most long-lived individuals among colony members. How can termite kings maintain high sexual activity over several decades without sacrificing longevity? Because of their unique characteristics, termite kings are expected to facilitate the discovery of the novel mechanisms underlying the extremely long longevity.

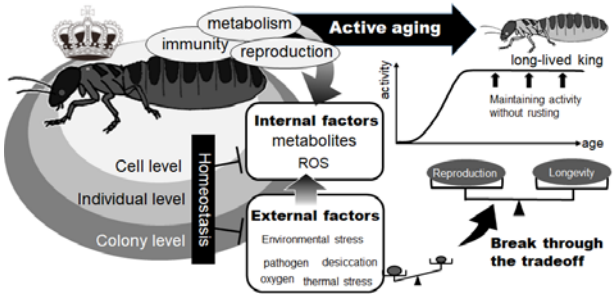


Figure 1. Research scheme

【Research Methods】

To identify metabolic pathway and the metabolic activity of the kings changing as aging, we perform metabolic flux analyses using doubly labeled water method and isotope distribution from 13C-labeled compounds.

Kings and queens have no symbiotic protozoa in their hindgut, and food supply is made exclusively through trophallaxis from workers. Based on our long-term behavioral monitoring, we found that workers provide a special royal food for kings and queens. We are going to identify the key compounds of the royal food by using MS/MS and also perform in vivo function analysis of the candidate compounds.

Royal chambers, where kings and queens are harbored, have a lower oxygen concentration in comparison with other parts of the termite nests. To investigate how the hypoxic condition influence on kings' reproduction and longevity, we perform comparative analysis of their metabolism by keeping kings under different oxygen conditions.

【Expected Research Achievements and Scientific Significance】

Having healthy active life for a long time is one ideal of the human society. Through this study, we will be able to find a number of novel factors underlying the extreme longevity of termite kings, which acquired such a long longevity in the history of evolution independently of mammals. Identification of novel molecular mechanism underlying the extremely long lifespan of social insect royals would have a high interdisciplinary impact in biology.

【Publications Relevant to the Project】

・Matsuura K. et al. (2018) A genomic imprinting model of termite caste determination: Not genetic but epigenetic inheritance influences offspring caste fate. . Am Nat 191: 677-690.
・Matsuura, K. et al. (2009) Queen succession through asexual reproduction in termites. Science 323:1687.

【Term of Project】 FY2018-2022

【Budget Allocation】 149,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.insecteco.kais.kyoto-u.ac.jp/
kenjijpn@kais.kyoto-u.ac.jp

【Grant-in-Aid for Scientific Research (S)】

Broad Section F

Title of Project : Uncovering the secrets of lipid-transporting ABC proteins

Kazumitsu Ueda
(Kyoto University, Graduate School of Agriculture, Professor)

Research Project Number : 18H05269 Researcher Number : 10151789
Keyword : ABC proteins, cholesterol, transporter, atherosclerosis

【Purpose and Background of the Research】

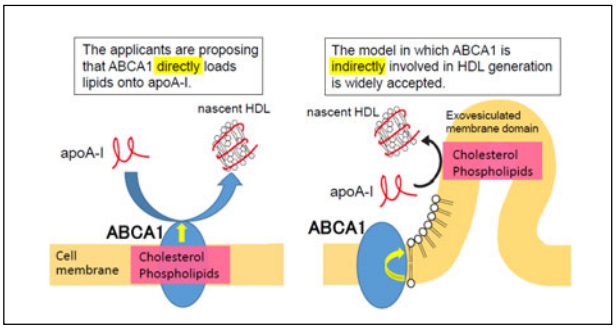
Genome analyses have revealed that 48 genes of the ATP-binding cassette (ABC) protein family are encoded on human chromosomes, and that defects in more than 20 family members are related to various diseases. Thus, ABC proteins play important roles for maintaining human health.

Ueda has been working on ABC proteins for 30 years, since the discovery of the multidrug transporter MDR1 (ABCB1), and recently succeeded in establishing a platform for ABC protein research by revealing the mechanism of MDR1 function based detailed structural analyses. In this project, we are aiming to reveal the mechanism of lipid-transporting ABC proteins, specifically ABCA1.

ABCA1 is a key transporter involved in the generation of high-density lipoprotein (HDL). However, the mechanism of HDL generation remains controversial. According to a widely accepted model for HDL generation, ABCA1 generates specific membrane domains (i.e., exovesiculated membrane domains) with outward phospholipid translocation activity, and apoA-I (a lipid acceptor in serum) spontaneously acquires lipids from these domains (Fig). Based on our biochemical and cell biological data, we propose "the direct loading model," a mechanism quite different from the conventional model.

【Research Methods】

To provide answers to unsolved questions in this field, we will integrate a variety of scientific and technical disciplines, including single molecule imaging, cryo-electron microscopy, high-speed AFM, high-resolution X-ray crystallography, and studies in model organisms in addition to conventional biochemistry and cell biology.



Models of HDL formation

We recently reported that ABCA1 is involved in the uneven distribution of cholesterol in the plasma membrane. Our ongoing studies will reveal the mechanism by which ABCA1 function is regulated. Lipid-transporting ABC proteins are thought to be involved in neurological diseases such as Alzheimer's. Our studies will reveal their roles in these disorders using model organisms.

【Expected Research Achievements and Scientific Significance】

Collapse of cholesterol homeostasis causes various diseases. However, the mechanism by which this homeostasis is maintained remains unclear, and the physiological role of cholesterol is not well understood. By revealing the mechanism underlying HDL generation and novel physiological functions of cholesterols, our study will facilitate the development of methods to cure and prevent diseases such as atherosclerosis, diabetes, and neurological diseases.

【Publications Relevant to the Project】

・Nagata KO, *et al.* ABCA1 dimer-monomer interconversion during HDL generation revealed by single-molecule imaging. **Proc. Natl. Acad. Sci. USA**, 110, 5034-5039 (2013)
・Liu SL, *et al.* Orthogonal lipid sensors identify transbilayer asymmetry of plasma membrane cholesterol. **Nature Chem Biol** 13, 268-274 (2017)
・Ishigami M, *et al.* Temporary sequestration of cholesterol and phosphatidylcholine within extracellular domains of ABCA1 during nascent HDL generation. **Sci Rep.** 8:6170 (2018)

【Term of Project】

FY2018-2022

【Budget Allocation】

148,900 Thousand Yen

【Homepage Address and Other Contact Information】

http:// www.biochemistry.kais.kyoto-u.ac.jp/
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Title of Project : Designing the mammalian biological oscillators

Hiroki R. Ueda
(The University of Tokyo, Graduate School of Medicine, Professor)

Research Project Number : 18H05270 Researcher Number : 20373277
Keyword : Synthetic biology

【Purpose and Background of the Research】

We have demonstrated that the activity of Casein kinase I (CKI) δ/ε plays a critical role in the determination of the period length of mammalian circadian clocks, of which the transcription and translation loop was believed to be the core design principle of the oscillator. We revealed that CKIδ/ε's phosphorylation activity is almost constant over the physiological range of temperature and is partly responsible for the temperature compensation of mammalian circadian clocks, that is, the period length of the circadian clock does not depend on the environmental temperature (Refs 1-2). Therefore, part of the design principle of mammalian circadian oscillators lies in the phosphorylation reaction.

In vivo phosphorylation dynamics is reversibly controlled by the presence of dephosphorylation activity. The primary purpose of this study is to clarify the mechanisms responsible for the dephosphorylation reaction antagonizing the phosphorylation of CKIδ/ε in the control of mammalian circadian clocks.

【Research Methods】

We have established an in vitro system to reconstitute the CKIδ/ε phosphorylation reaction corresponding to the control of the mammalian circadian clocks. With this system, the dephosphorylation enzyme activity antagonizing phosphorylation by CKIδ/ε will be searched. Furthermore, how this dephosphorylation activity is controlled by the phase of the circadian clock will be investigated (Fig. 1). The significance of identified dephosphorylation mechanism in vivo will be rigorously tested by the circadian-functional complementary system in mice (Ref. 3).

We will then reconstitute the dephosphorylation mechanism in the in vitro CKIδ/ε assay system to ask whether the reconstituted reversible phosphorylation reaction shows the property as the oscillator of the mammalian circadian clocks. Given the fact that temperature-independent phosphorylation property is conserved in CKI homolog of yeast, which apparently shows no circadian clock function, we will also design the reversible phosphorylation system to ask whether the idea of phosphorylation-driven oscillators is applicable for the non-circadian biological oscillators.

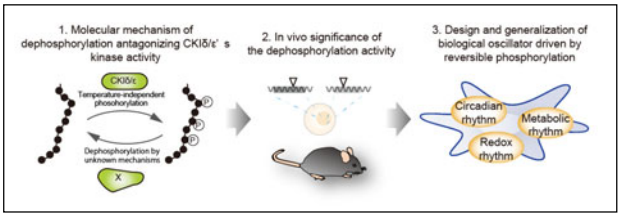


Figure 1 Oscillators driven by phosphorylation

【Expected Research Achievements and Scientific Significance】

This research will propose a new paradigm of the design principle of a mammalian oscillator by reversible phosphorylation. Also, by examining the possibility that reversible phosphorylation can drive biological oscillation involving CKI other than circadian clocks, the impact will be beyond the field of the circadian clock.

【Publications Relevant to the Project】

1. Isojima *et al.*, CKI ε/δ-dependent phosphorylation is a temperature-insensitive, period-determining process in the mammalian circadian clock. *Proc. Natl. Acad. Sci. USA*, 106, 15744-15749 (2009)
2. Shinohara *et al.*, Temperature-Sensitive Substrate and Product Binding Underlie Temperature-Compensated Phosphorylation in the Clock. *Mol. Cell*, 67, 783-798 (2017)
3. Ode *et al.*, Knockout-rescue embryonic stem cell-derived mouse reveals circadian-period control by quality and quantity of CRY1. *Mol. Cell*, 65, 176-190 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 154,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://sys-pharm.m.u-tokyo.ac.jp/index.html

【Grant-in-Aid for Scientific Research (S)】

Broad Section G

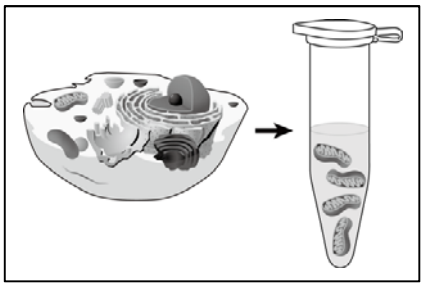
Title of Project : Biochemical approaches to understanding the reaction platforms of the piRNA pathway

Yukihide Tomari
(The University of Tokyo, Institute for Quantitative Biosciences, Professor)

Research Project Number : 18H05271 Researcher Number : 90447368
Keyword : piRNAs, small RNAs, reaction platform, RNA silencing, PIWI, Argonaute

【Purpose and Background of the Research】

Since the discovery of RNA interference, our biochemical understanding of small RNAs has been greatly advanced. However, there remain many unknowns in the molecular mechanism of piRNAs, which play essential roles in protecting the germline cells from transposons. The biggest obstacle is that piRNAs require specific "reaction platforms" in cells for their biogenesis and function, and thus the natural activity can be easily lost in conventional biochemical approaches using soluble lysates prepared by high-speed centrifugation, purified recombinant proteins etc.
We have previously established a cell-free system that recapitulates a part of the piRNA biogenesis pathway using the whole mitochondrial fraction. In this project, we propose to further develop this unique in vitro system so as to precisely understand the biogenesis and function of the piRNA pathway at the molecular level.



Biochemical approaches to understanding the reaction platforms

【Research Methods】

In particular, we will focus on the following three questions.

1. How are piRNA intermediates loaded into PIWI proteins?
2. How are piRNA intermediates processed into mature piRNAs?
3. How are the piRNA-cleaved targets are properly handed over to the next PIWI protein?

We seek to extract the corresponding "reaction platforms" from cells to test tubes in their best intact forms, faithfully recapitulate the processes and monitor the on-site reactions. We will not only utilize biochemistry to dissect the reactions into fundamental steps, but also combine it with genome editing technologies, next-generation sequencing, bioinformatics etc.

【Expected Research Achievements and Scientific Significance】

Our molecular understanding of the piRNA pathway is still lacking in vague models. This project takes advantage of our unique knowledge and approaches to the characteristic features of piRNAs that depend on cellular "reaction platforms" and aims at breaking the deadlock in the field. The idea of "reaction platform"-focused biochemistry is not limited to the piRNA pathway but could also be applicable to various non-coding RNAs and other biological processes that relies on cellular platforms.

【Publications Relevant to the Project】

Structural basis for arginine methylation-independent recognition of PIWIL1 by TDRD2. Zhang H, Liu K, Izumi N, Huang H, Ding D, Ni Z, Sidhu SS, Chen C, *Tomari Y, *Min J. ***Proc Natl Acad Sci U S A.*** 2017 Nov 21;114(47):12483-12488.

Identification and functional analysis of the pre-piRNA 3′ Trimmer in silkworms. Izumi N, Shoji K, Sakaguchi Y, Honda S, Kirino Y, Suzuki T, Katsuma S, *Tomari Y. ***Cell.*** 2016 Feb 25;164(5):962-73.

3′-end formation of PIWI-interacting RNAs in vitro. Kawaoka S, Izumi N, *Katsuma S, *Tomari Y. ***Mol Cell.*** 2011 Sep 16;43(6):1015-22.

【Term of Project】 FY2018–2022

【Budget Allocation】 148,900 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Dynamic regulation of RNA modification and biological process

Tsutomu Suzuki
(The University of Tokyo, Graduate School of Engineering, Professor)

Research Project Number : 18H05272 Researcher Number : 20292782
Keyword : RNA modification, mRNA, tRNA, ribosome, metabolite

【Purpose and Background of the Research】

RNA molecule has been regarded as a regulatory element in gene expression at the levels of transcription and translation, and is associated with various biological processes. RNA molecules are decorated with a wide variety of chemical modifications that are introduced after transcription. This process is also referred to as “epitranscriptome” that generates an emerging field in life science. We found some instances of RNA modifications dynamically regulated by sensing cellular metabolites which are substrates of the RNA modifications. In this project, we aim to establish a novel concept of regulatory gene expression mediated by dynamic regulation of RNA modification by sensing cellular metabolic status.

【Research Methods】

Individual RNAs are isolated by our original method called ‘reciprocal circulating chromatography (RCC)’. A species and site of each modification in the isolated RNA are analyzed by a highly sensitive detection system for RNA molecules using mass spectrometry (RNA-MS). In this project, we focus on RNA modification dynamically regulated by various cellular conditions including environmental stresses and nutrient starvation by measuring frequency of RNA modification using RNA-MS. We also explore RNA-modifying enzymes, enabling us to study RNA modification biochemically as well as genetically.

【Expected Research Achievements and Scientific Significance】

It is widely known that gene expression is transcriptionally regulated by various cellular processes including development and differentiation in spaciotemporal manner. We have been focusing on dynamic alteration of RNA modification as a novel regulatory element in gene expression. This project aims to establish a novel concept of regulatory mechanism of gene expression by dynamic alteration of RNA modification by sensing cellular metabolic status. Especially, we study RNA modifications regulated by nutritional availability and respiratory conditions. We also study physiological importance of reversible RNA modifications. Understanding of molecular pathogenesis of RNA modopathies will contribute to medical and pharmaceutical applications.

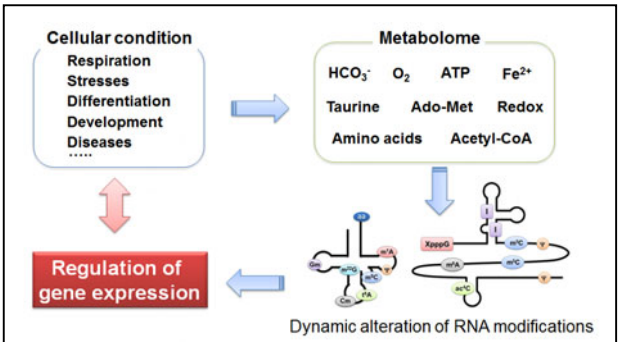

Figure Dynamic regulation of RNA modifications by sensing cellular metabolic status

【Publications Relevant to the Project】

- Taniguchi et al., Acetate-dependent tRNA acetylation required for decoding fidelity in protein synthesis. ***Nature Chem Biol.***, in press (2018)
- Lin et a., CO_2-sensitive tRNA modification associated with human mitochondrial disease. ***Nature Commun.***, 14, 9(1):1875 (2018)
- Nagao et al., Hydroxylation of a conserved tRNA modification establishes non-universal genetic code in echinoderm mitochondria. ***Nature Struct Mol Biol.***, 24, 778-782 (2017)
- Frye et al., RNA modifications: what have we learned and where are we headed? ***Nature Rev Genet.***, 17, 365-372 (2016)

【Term of Project】 FY2018-2022

【Budget Allocation】 149,800 Thousand Yen

【Homepage Address and Other Contact Information】

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Title of Project : Spectral opponency in photoreceptors : neuroethological analysis

Kentaro Arikawa
(SOKENDAI – The Graduate University for Advanced Studies, School of Advanced Sciences, Professor)

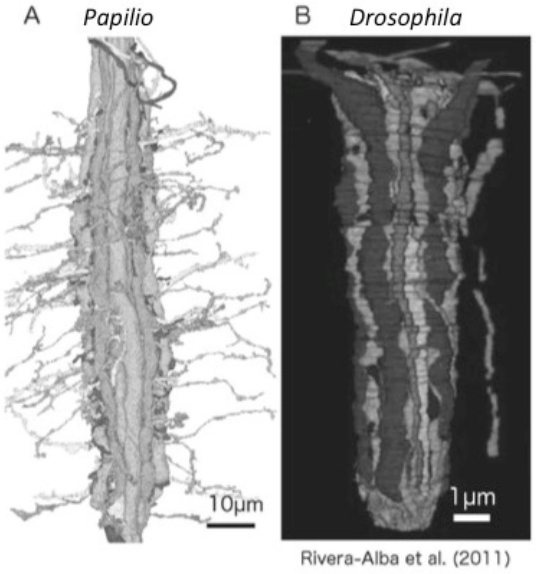
Research Project Number : 18H05273 Researcher Number : 20167232
Keyword : insect, color vision, photoreceptor, lamina, spectral opponency

【Purpose and Background of the Research】

We focus on the interphotoreceptor synapses in the lamina to study mechanisms of insect color vision. The interphotoreceptor synapses are presumably inhibitory, which we first identified in the butterfly, *Papilio xuthus*. *Papilio* has six distinct spectral receptors in the eye, and has long been a model species for color vision study. What would happen if spectrally distinct photoreceptors mutually inhibit? What is transmitted to second order neurons? Such photoreceptor interactions are absent in the lamina of *Drosophila*, which is perhaps related to their limited ability of discriminating colors. We hypothesize that the interphotoreceptor synapses provide crucial elements for color vision, and will analyse their function in the *Papilio* lamina. We will also perform comparative functional anatomy of the lamina in a variety of insects to address the question how color vision has evolved.

【Research Methods】

We will take three approaches: *i*) spectral opponency in photoreceptors, *ii*) LMCs' spectral properties, the second order neurons in the lamina, *iii*) comparative anatomy of the lamia among insects. CRISPR-Cas9 method will be applied to produce genetically-modified *Papilio*, which will be compared with normal individuals to understand the basis of wavelength information processing in the lamina. The comparative anatomy will aim at collecting serial images sufficient for analyzing lamina circuit at the EM level. We will start analyzing the lamina of about 10 insect species where vision has been somewhat studied.



3D reconstruction of photoreceptors and LMCs in the lamina cartridge. Lateral processes are missing in *Drosophila*.

【Expected Research Achievements and Scientific Significance】

Color vision is wide spread among animals, and even insects often exhibit human-like color vision properties. However, insects' nervous systems are quite different from that of vertebrates, indicating that the similarity is due to convergent evolution. Pioneered by Karl von Frisch, study of insect color vision has been a main topic of neuroethology. Recent progress in this field is quite impressive in *Drosophila* where all the contemporary molecular biological techniques are available. However, color vision of these flies is quite limited, while butterflies are the champion animals in this regard. This project using butterflies will reveal the neuronal mechanisms underlying their sophisticated color vision, together with its evolutionary background, which would enlighten the essential parts for seeing colors.

【Publications Relevant to the Project】

- Arikawa. *J Physiol*, 16: 5457-64, 2017
- Perry *et al. Nature*, 535: 280–4, 2016
- Kinoshita, Arikawa. *J Comp Physiol A*, 200: 513-26, 2014
- Takemura, Arikawa. *J Comp Neurol*, 494: 663-72, 2006
- Takeuchi *et al. J Exp Biol*, 209: 2873-9, 2006

【Term of Project】

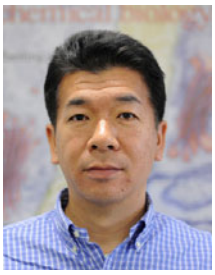
FY2018-2022

【Budget Allocation】

154,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.esb.soken.ac.jp/research/index.html#kentaro_arikawa



Title of Project : Molecular dissection of peptide signaling in plants

Yoshikatsu Matsubayashi
(Nagoya University, Graduate School of Science, Professor)

Research Project Number : 18H05274　Researcher Number : 00313974
Keyword : Peptide hormone, Receptor, *Arabidopsis*

【Purpose and Background of the Research】

Identification of hormones and their receptors in multicellular organisms is one of the most exciting research areas leading to breakthroughs in understanding how their growth and development are regulated. In particular, peptide signals offer advantages as cell-to-cell signals in that they have the most diversity in structure and function. Our goal in this project is to uncover the mechanisms by which plant development is regulated through identification of novel peptide signals and their receptors by using genome information, biochemical analysis and phenotypic observation.

【Research Methods】

Identification of novel peptide hormones by *in silico* screening:

By using *Arabidopsis* protein database, we will perform *in silico* screening of peptide hormone candidates based on the structural characteristics of the known peptide hormones. After structural elucidation by LC-MS/MS, we will identify receptors for peptides by exhaustive binding assay using receptor kinase expression library. Once we identified peptide ligand-receptor pairs, we will analyze their physiological roles in detail.

Ligand fishing using immobilized receptors:

We will use receptor-immobilized column to directly purify specific ligands in one step from the crude samples. We employ this approach to determine natural structures of peptide elicitors involved in disease resistance of plants.

Phloem-specific long distance mobile peptides:

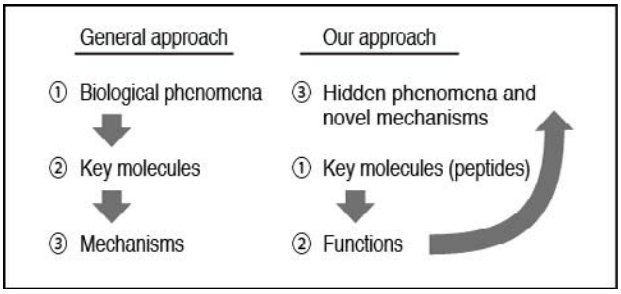


Figure 1　Outline of our experimental approach

Based on the tissue-specific microarray data, we have obtained several non-secreted peptides that show phloem-specific expression in leaves. They are strong candidates for shoot-to-root long distance mobile peptides. We will analyze their functions by combination of reverse genetics and biochemistry.

【Expected Research Achievements and Scientific Significance】

Ligand-receptor pairs act as master switches of complex intracellular signaling that directly regulates plant growth and development. Molecular dissection of these signaling pathway greatly promote our understanding of plant growth mechanisms under fluctuating natural environment. Moreover, these signaling pathways are attractive targets for the development of novel plant growth regulators.

【Publications Relevant to the Project】

・Tabata R., Sumida K., Yoshii T., Ohyama K., Shinohara H., Matsubayashi Y. Perception of root-derived peptides by shoot LRR-RKs mediates systemic N-demand signaling. *Science* **346,** 343-346 (2014)
・Ohkubo Y., Tanaka M., Tabata R., Ogawa-Ohnishi M., Matsubayashi Y. Shoot-to-root mobile polypeptides involved in systemic regulation of nitrogen acquisition. *Nature Plants* **3**, 17029 (2017)
・Nakayama T., Shinohara H., Tanaka M., Baba K., Ogawa-Ohnishi M., Matsubayashi Y. A peptide hormone required for Casparian strip diffusion-barrier formation in *Arabidopsis* roots. *Science* **355,** 284-286 (2017)

【Term of Project】 FY2018-2022

【Budget Allocation】 148,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.bio.nagoya-u.ac.jp/~b2/research4.html

Title of Project : Full elucidation of sorting mechanisms in and around the Golgi apparatus by super-resolution live imaging

Akihiko Nakano
(RIKEN Center for Advanced Photonics, Deputy Director)

Research Project Number : 18H05275 Researcher Number : 90142140
Keyword : membrane traffic, Golgi apparatus, sorting and transport

【Purpose and Background of the Research】

Understanding of the mechanisms of membrane trafficking is now being totally innovated by state-of-the-art super-resolution live imaging microscopy. We have recently developed a new method with an extremely high spatiotemporal resolution, which can track dynamic 4D behaviors of even vesicles in cytoplasm. With this technology, we will tackle fundamental questions underlying the transport processes in the secretory pathway, from the ER to the Golgi apparatus and further to the *trans*-Golgi network. Experts on yeast, plant and animal cells will compare corresponding transport processes and extract common mechanisms and different features and draw comprehensive models, which will lead to thorough understanding of molecular mechanisms.

【Research Methods】

By making full use of SCLIM2 we developed, we will investigate the following problems.
[Yeast cells] 1) cargo capture from the ER by *cis*-Golgi; 2) cargo delivery between Golgi cisternae; 3) spatiotemporal regulation of sorting in the TGN.
[Plant cells] 1) cargo capture from the ER by GECCO; 2) cargo delivery in the Golgi stack; 3) spatiotemporal regulation of sorting in the TGN.
[Animal cells] 1) cargo capture from the ER by ERGIC; 2) cargo delivery in the Golgi stack and the TGN; 3) roles of the Golgi in nerve axons.

【Expected Research Achievements and Scientific Significance】

SCLIM, super-resolution confocal live imaging microscopy, has been a powerful tool to examine dynamic processes of membrane trafficking. We have further improved its performance by raising the sensitivity and the speed of detection system (Figure 1). By single-photon counting and a new deconvolution algorithm we developed, it now enables us to visualize assembly of coat proteins on the organelle membranes, sorting and packaging of cargo, handover of cargo between compartments, etc. which we have been eager to unveil.

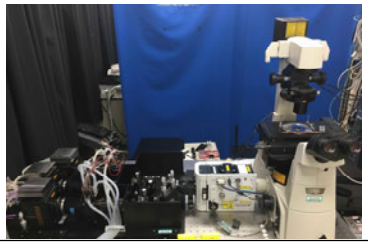


Figure 1 SCLIM2

【Publications Relevant to the Project】

- Ito, Y., Uemura, T., and Nakano, A. (2018). Golgi Entry Core Compartment functions as the COPII-independent scaffold for ER-Golgi transport in plant cells. *J. Cell Sci.* 131:jcs203893.
- Ishii, M., Suda, Y., Kurokawa, K., and Nakano, A. (2016). COPI is essential for Golgi cisternal maturation and dynamics. *J. Cell Sci.* 129:3251-3261.
- Kurokawa, K., Suda, Y. and Nakano, A. (2016). Sar1 localizes at the rims of COPII-coated membranes *in vivo*. *J. Cell Sci.* 129:3231-3237.
- Kurokawa, K., Okamoto, M., and Nakano, A. (2014). Contact of *cis*-Golgi with ER exit sites executes cargo capture and delivery from the ER. *Nat. Commun.* 5:3653.
- Uemura, T., Suda, Y., Ueda, T., and Nakano, A. (2014). Dynamic behavior of the *trans*-Golgi network in root tissues of Arabidopsis revealed by super-resolution live imaging. *Plant Cell Physiol.* 55:694-670.
- Suda, Y., Kurokawa, K., Hirata, R., and Nakano, A. (2013). Rab GAP cascade regulates dynamics of Ypt6 during the Golgi maturation. *Proc. Natl. Acad. Sci. U. S. A.* 110:18976-18981.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,300 Thousand Yen

【Homepage Address and Other Contact Information】

https://rap.riken.jp/en/labs/sprg/lcmirt/

Title of Project : Molecular mechanisms of condensins I and II

Tatsuya Hirano
(RIKEN, Cluster for Pioneering Research, Chief Scientist)

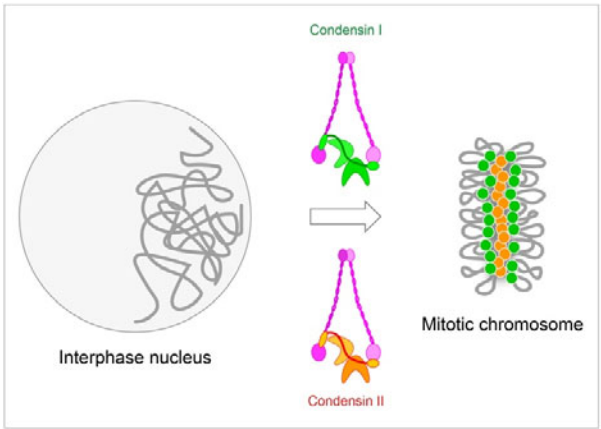
Research Project Number : 18H05276 Researcher Number : 50212171
Keyword : Biochemistry, Cell Biology, Mathematical Biology, Chromosomes, Cell Division

【Purpose and Background of the Research】

The assembly of mitotic chromosomes is an essential process for the faithful segregation of duplicated genetic materials into daughter cells. Our group discovered two types of protein complexes, now known as condensins I and II, that play central roles in this process, and made substantial contributions to our understanding of their cellular functions and molecular mechanisms of action. More recently, we have succeeded in reconstituting a mitotic chromosome structure with purified protein components including condensin I, and further demonstrated that a chromosome-like structure can be assembled even in the near-absence of nucleosomes in a condensin-dependent manner. The goal of this research project is to elucidate the molecular mechanisms of condensins I and II by combining two complementary approaches, namely, biochemistry and mathematical modeling (Figure below).

【Research Methods】

(1) We will reconstitute condensins I and II from their recombinant subunits, purify them, and test their ability to assemble chromosomes in *Xenopus* egg cell-free extracts. In addition to the wild-type holocomplex, holocomplexes harboring point mutations and subcomplexes lacking one or two of the regulatory subunits will be tested to understand how the two condensin complexes might work and collaborate with each other.
(2) We will establish a protocol in which the recombinant complexes can be activated in vitro by Cdk1-mediated phosphorylation, and thoroughly compare the biochemical activities of condensin I with those of condensin II.
(3) We will take an approach of mathematical modeling and computer simulation to get deeper insights into the action of condensins I and II. Such a theoretical approach will not only complement the experimental approach, but also provide us with hints about designing a new set of innovative experiments.



【Expected Research Achievements and Scientific Significance】

The question of how mitotic chromosomes might assemble is arguably one of the biggest questions left in the field of modern cell biology. It is anticipated that this research project will help uncover a whole molecular picture of how condensins I and II cooperate to assemble mitotic chromosomes at a mechanistic level. The outcome of this project will have a broad impact on our understanding of how anomalies of chromosome architecture cause human diseases including cancers and birth defects.

【Publications Relevant to the Project】

・Kinoshita, K., T. J. Kobayashi, and T. Hirano. (2015). Balancing acts of two HEAT subunits of condensin I support dynamic assembly of chromosome axes. *Dev. Cell.* 33:94-106.
・Hirano, T. (2016). Condensin-based chromosome organization from bacteria to vertebrates. *Cell.* 164:847-857.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.riken.jp/chromdyna/

【Grant-in-Aid for Scientific Research (S)】

Broad Section H

Title of Project : Sulfur-mediated energy metabolism, sulfur respiration: Its discovery and physiological functions

Takaaki Akaike
(Tohoku University, Graduate School of Medicine, Professor)

Research Project Number : 18H05277 Researcher Number : 20231798
Keyword : Reactive sulfur species, energy metabolism, sulfur respiration

【Purpose and Background of the Research】

Many organisms utilize the oxygen-dependent energy metabolism, known as oxygen respiration. Because of hypoxic and anaerobic environments for the cells and tissues such as stem cells, muscles and tumors, any alternative energy-producing pathway is required to maintain the homeostasis of cellular physiological functions. Versatile reactive sulfur species has been suggested to be involved in the oxygen-independent energy production system for ancient cells, and prokaryotic organisms, because of its similar chemical properties to molecular oxygen and of its widespread presence in the natural environments like volcanos, hot springs, etc.

We have clarified the abundant formation of reactive sulfur species (RSS), like cysteine persulfide (CysSSH) which has an additional sulfur atom to cysteine (CysSH) in various organisms, including prokaryotes and mammals. More recently, we identified a novel metabolic pathway for CysSSH biosynthesis, mediated by cysteinyl-tRNA synthetases and revealed that CysSSH and its metabolites can be utilized for the energy production process instead of oxygen. This finding is groundbreaking and paradigm-shifting indeed, and we termed the new energy metabolism as the "sulfur respiration (Figure 1)".

Our particular research project aims therefore to comprehensively understand the molecular mechanism and physiological functions of sulfur respiration, which is the most fundamental system of life but is yet almost unknown, and finally aims at establishing the new central dogma, which would greatly promote the human health, disease control, and improved longevity.

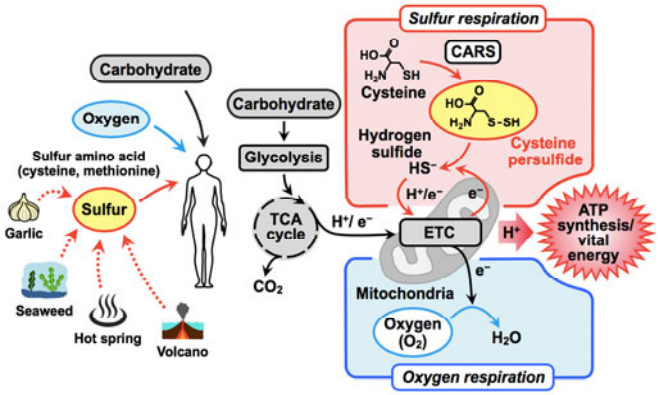


Figure 1. Sulfur respiration

【Research Methods】

We will clarify the mechanisms of the sulfur respiration in vivo, based on the chemical biology, biochemistry, cell biology and redox biology of RSS, as well as by using animal models to be develped herein for the sulfur respiration utilizing gene-editing techniques (Figure 2). The translational applications based on the insights obtained from this proposed research will be also conducted.

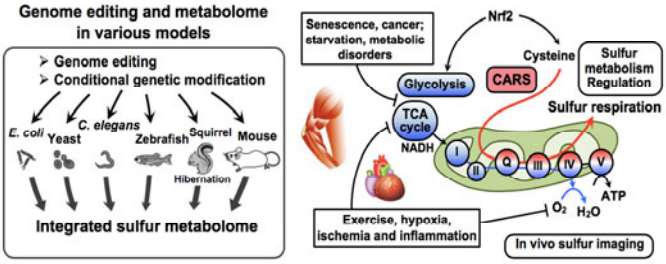


Figure 2. Research plans

【Expected Research Achievements and Scientific Significance】

The theoretical and molecular basis for the sulfur respiration that will be established by this project could provide novel strategies for anti-aging or improving human longevity and contribute to newly develop diagnoses, preventions and therapeutic approach for various diseases, including chronic or intractable cancer and infections, atherosclerotic vascular and cardiac diseases. In addition, the sulfur metabolites, or reactive sulfur species (including their antidotes) can be capitalized as biomarkers, and applicable for regulating the sulfur respiration, on which several malignant cancers may be addicted or the stem cells and other particular cells and tissues may depend especially under hypoxic and anaerobic conditions.

【Publications Relevant to the Project】

・Ida T et al. Reactive cysteine persulfides and S-polythiolation regulate oxidative stress and redox signaling. *Proc Natl Acad Sci USA* 111: 7606-7611 (2014).
・Akaike T et al. Cysteinyl-tRNA synthetase governs cysteine polysulfidation and mitochondrial bioenergetics. *Nat Commun* 8: 1177 (2017).

【Term of Project】 FY2018-2022

【Budget Allocation】 148,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.toxicosci.med.tohoku.ac.jp/index.html

Title of Project : Analysis of immune regulatory mechanisms mediated by mRNA metabolism

Osamu Takeuchi
(Kyoto University, Institute for Frontier Life and Medical Sciences, Professor)

Research Project Number : 18H05278 Researcher Number : 10379092
Keyword : immune reaction, cytokine, mRNA decay

【Purpose and Background of the Research】

Immune cells eliminate pathogens by evoking immune responses by recognizing pathogens via a set of receptors such as Toll-like receptors and antigen-receptors. Cytokines are mediators of immune responses, although their production is tightly controlled to prevent inflammatory diseases. We previously identified Regnase-1 as an RNase essential for the suppression of excess immune responses. Regnase-1 post-transcriptionally controls abundance of mRNAs related with immune responses by directly degrading them. Furthermore, the studies on Regnase-1 and Roquin revealed that immune responses are fine-tuned by spatiotemporally-regulated decay of mRNAs in cells. The immune-related mRNAs are controlled not only by 3' untranslated regions (UTR) recognized by Regnase-1, but also via the coding regions and the modification of mRNAs. Although the abundance of immune-related mRNAs is determined by highly complex mRNA metabolism, the mechanism of regulation is not understood yet. In this research, we aim to elucidate the dynamic network of mRNA metabolism in immune regulation.

【Research Methods】

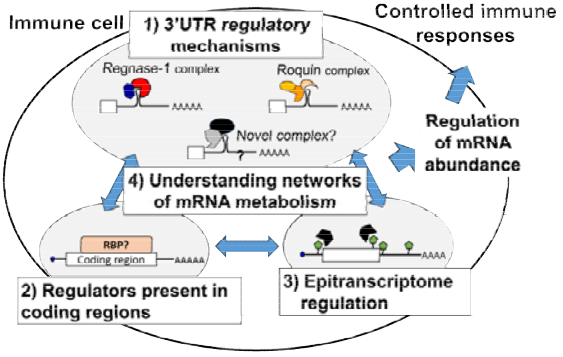


Fig. 1. Scheme of this research

In this research, we will analyze mechanisms of mRNA regulation in immune responses via following points of view.

1) Analysis of spatiotemporal regulation of immune-related mRNAs via 3' UTR.
2) Analysis of molecular mechanisms of immune-related mRNAs hidden in protein coding regions.
3) Roles of mRNA epitranscriptome in the regulation of immune reactions.

Then, the networks between immune regulatory systems studied in 1) ~3) will be integrated by in silico analysis such as machine learning.

【Expected Research Achievements and Scientific Significance】

We will try to understand dynamic mRNA metabolism networks in the control of immune responses. Further integration between mRNA regulation and transcription networks, complete understanding of gene expression networks of immune reactions will be achieved. In addition, our study will lead to the precise prediction of immune responses, which might be leading to the development of novel therapies targeting mRNA metabolisms.

【Publications Relevant to the Project】

・Yoshinaga M, Nakatsuka Y, Vandenbon A, Ori D, Uehata T, Tsujimura T, Suzuki Y, Mino T, Takeuchi O. Regnase-1 Maintains Iron Homeostasis via the Degradation of Transferrin Receptor 1 and Prolyl-Hydroxylase-Domain-Containing Protein 3 mRNAs. ***Cell Rep.*** 19:1614-1630. 2017
・Mino T, Murakawa Y, Fukao A, Vandenbon A, Wessels HH, Ori D, Uehata T, Tartey S, Akira S, Suzuki Y, Vinuesa CG, Ohler U, Standley DM, Landthaler M, Fujiwara T, Takeuchi O. Regnase-1 and Roquin Regulate a Common Element in Inflammatory mRNAs by Spatiotemporally Distinct Mechanisms. ***Cell***. 161:1058-73. 2015

【Term of Project】 FY2018-2022

【Budget Allocation】 148,900 Thousand Yen

【Homepage Address and Other Contact Information】

https://www2.infront.kyoto-u.ac.jp/Takeuchi_HP/

【Grant-in-Aid for Scientific Research (S)】

Broad Section H

Title of Project : Studies on the regulation of infection and immunity via paired receptors

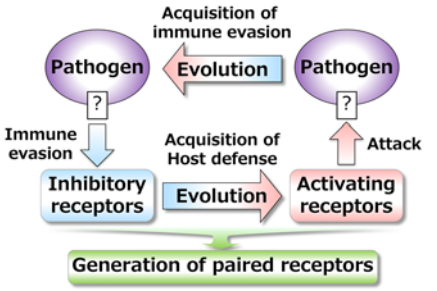
Hisashi Arase
(Osaka University, Research Institute for Microbial Diseases, Professor)

Research Project Number : 18H05279 Researcher Number : 10261900
Keyword : Paired receptors, Host-pathogen interaction, Immune evasion

【Purpose and Background of the Research】

Immune system express a series of paired receptors that consist of inhibitory and activating receptors. We have elucidated the function of various paired receptors based on our original hypothesis that the paired receptors have evolved with viruses (***Cell*** 2008; ***Nat. Immunol.*** 2012). Furthermore, we have shown that paired receptors are involved in not only virus infection but also in bacterial and malaria infection (***Nat. Microbiol.*** 2016, ***Nature*** 2017 Fig. 1). In this study, we would like to elucidate how pathogens are using inhibitory paired receptors for immune evasion. In addition, we will elucidate the function of paired receptors in host defense mechanism. Based on the studies on host-pathogen interaction, function of paired receptors in autoimmune diseases and allergic diseases will be elucidated.

Fig. 1 Coevolution of paired receptors with pathogens



【Research Methods】

We will perform the following studies. 1. We will identify the pathogen ligands for paired receptors. 2. We will study the role of paired receptors in severe infection, persistent infection or latent infection. 3. We will study the contribution of in paired receptors in autoimmunity or allergic diseases.

- **Studies on the function of paired receptors in infectious diseases.**

We will elucidate the interactions of various paired receptors with malaria molecules like FIRINs Furthermore, association of RIFIN expression and severe malaria will be elucidated. Furthermore, function of paired receptors in persistent and latent infection of virus as well as viral reactivation will be analyzed.

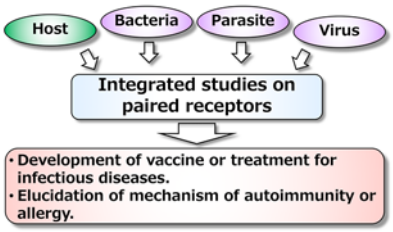
- **Studies on relationship between polymorphisms of paired receptors and diseases.**

By analyzing polymorphism of paired receptors from both host and pathogen side, we will elucidate the mechanism of autoimmunity or allergy.

【Expected Research Achievements and Scientific Significance】

Total function of paired receptors in host-pathogen interaction will be elucidated in this study. In addition, involvement of paired receptors in immune homeostasis will be elucidated. This study will be important to develop a method for prevention or treatment of infectious and immune diseases as well as vaccines (Fig. 2).

Fig. 2 Studies on regulation of infection and immunity via paired receptors



【Publications Relevant to the Project】

- Saito F, 17 others, Arase H. Immune evasion of *Plasmodium falciparum* by RIFIN via inhibitory receptors. ***Nature*** 552: 101-105, 2017.
- Hirayasu K, 14 others, Arase H. Microbially cleaved immunoglobulins are sensed by the innate immune receptor LILRA2. ***Nature Microbiology*** 25: 16054, 2016.
- Wang J, 3 others, Arase H. Neutrophil infiltration during inflammation is regulated by PILRα via modulation of integrin activation. ***Nature Immunology*** 14: 34-40, 2013.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://immchem.biken.osaka-u.ac.jp
arase@biken.osaka-u.ac.jp

Title of Project : Multi Regulatory System for Gut Homeostasis and Inflammation

Hiroshi Kiyono
(The University of Tokyo, The Institute of Medical Science, Distinguished Professor)

Research Project Number : 18H05280 Researcher Number : 10271032
Keyword : Mucosal Immunology, Organ association, Inflammatory bowel diseases

【Purpose and Background of the Research】

Intestinal mucosa senses the alteration of nutrients and commensal bacteria and modulates both maintenance of homeostasis/ induction of pathogenesis. The important effects of the intestine in the regulation of physiological function beyond the organ has been well recognized, so that it is called the "Super organ."

Crohn's disease is a chronic inflammatory disease occurring in the intestinal mucosa. It has been reported that patients of Crohn's disease show inflammation and dysfunction in not only mucosa but surrounding tissues, such as pancreas and *Muscularis externa*. In addition, complications associated with Crohn's disease develop in the remote organs such as eyes and joints. However, the detailed mechanism of the crosstalk between surrounding tissues, or mucosa-supportive tissues, and intestinal mucosa has not been revealed yet.

With our past researches of mucosal immune system together with pioneering and accumulated profound knowledge/skills, we aim to elucidate mucosal defense mechanisms which is mediated by the gut hierarchically-organized mucosal supportive system.

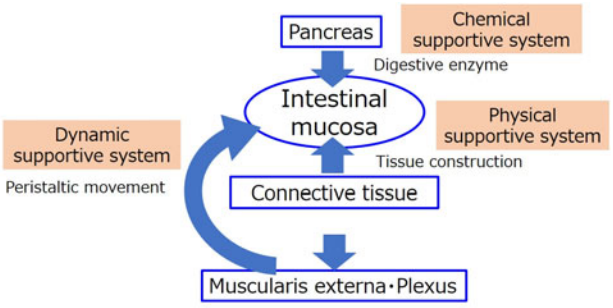


Figure 1. The gut hierarchically-organized mucosal supportive system

【Research Methods】

In this study, we focus on following organ or tissue association/crosstalk.

1. pancreas-intestinal association
2. mucosal-connective tissue association
3. mucosa-muscular association

It is thought that the breakdown of association/crosstalk leads to the intestinal pathogenesis, especially inflammatory bowel disease. By the creation of novel experimental disease models, we aim to reveal the multiple organ/tissue crosstalk systems. We also try to orchestrate these three research pieces for further understanding of gut hierarchically-organized mucosal supportive system.

【Expected Research Achievements and Scientific Significance】

The accomplishment of this study will provide further understanding of the contribution of mucosal system for systemic homeostasis and pathogenesis. In addition, we aim to establish the basis for therapeutic strategy of mucosal inflammation and its complications.

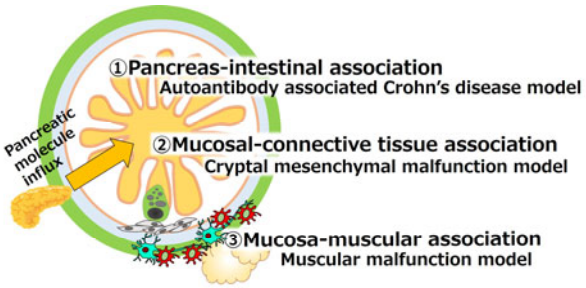


Figure 2. Understanding of mucosal supportive system and establishment of the therapeutic strategy

【Publications Relevant to the Project】

1. Kurashima Y and Kiyono H. Mucosal ecological network of epithelium and immune cells for gut homeostasis and tissue healing. *Ann Rev Immunol.* 35:119-147. 2017.
2. Goto Y, Uematsu S and Kiyono H. Epithelial glycosylation is a key immunological event for gut homeostasis and inflammation. *Nature Immunol.* 17(11):1244-1251. 2016.

【Term of Project】 FY2018-2022

【Budget Allocation】 147,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ims.u-tokyo.ac.jp/enmen/index_j.htm
http://www.m.chiba-u.jp/class/innovativemed/index.html

Title of Project : Molecular Analysis of Spermatogonial Stem Cell Aging

Takashi Shinohara
(Kyoto University, Graduate School of Medicine, Professor)

Research Project Number : 18H05281 Researcher Number : 30322770
Keyword : spermatogenesis, stem cells, aging

【Purpose and Background of the Research】

Germline stem (GS) cells proliferate in vitro as clumps of spermatogonia, but they can reinitiate spermatogenesis following spermatogonial transplantation. Unlike embryonic stem (ES) cells, GS cells are resistant to reactive oxygen species (ROS) and have a lower mutation frequency. Moreover, although GS cells express telomerase, their telomeres become shorter during two years of consecutive culture. These results suggest that GS cells have anti-aging machinery, which is different from those found in ES cells or somatic cells. We will analyze 1) the mechanism underlying telomere regulation in GS cells, 2) DNA repair or ROS resistance and 3) identify aging-inducing signals from somatic cells.

【Research Methods】

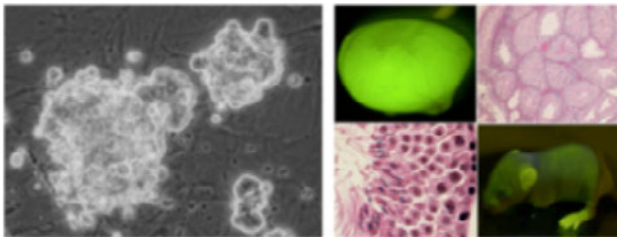


Figure 1 GS cells can differentiate into sperm

1) Analysis of telomere maintenance in GS cells
We will visualize the telomeres in GS cells and analyze the spatiotemporal distribution of telomeres. We will identify molecules involved in telomere maintenance in GS cells.
2) Analysis of DNA repair machinery and ROS level regulation in GS cells.
Cells in the germline lineage have a lower mutation frequency compared with somatic cells. However molecules involved in genome quality control have not been identified. We will analyze the impact of aging on mutation frequency and identify molecules involved in DNA repair.
3) Identification of aging inducing signals from somatic cells
Because germ cells do not show circadian rhythms. it is possible that testicular somatic cells induces germ cell aging. To identify these molecules, we will analyze gene expression patterns in aged animals from several species and identify genes responsible for testis aging.

【Expected Research Achievements and Scientific Significance】

Identification of telomere regulatory factors will bring new insight into telomere biology. Moreover, understanding the mechanism underlying the low mutation frequency in GS cells will open up a new field of germline genome quality control. The identification of aging-inducing signals from somatic cells will promote development of new strategies of male infertility treatment.

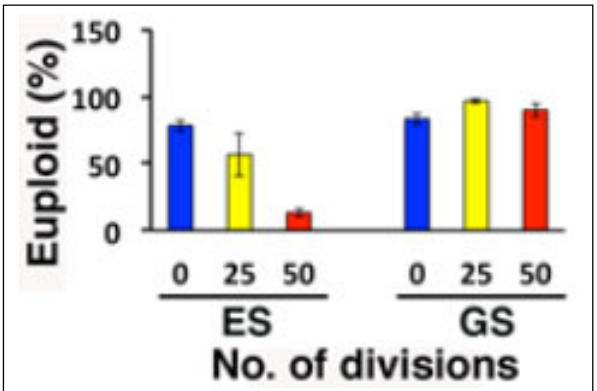


Figure 2 Karyotype stability of GS cells

【Publications Relevant to the Project】

・ Kanatsu-Shinohara, M.. et al. Nonrandom germline transmission of mouse spermatogonial stem cells. Dev. Cell 2016;38: 248-261.

【Term of Project】

FY2018-2022

【Budget Allocation】

148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www2.mfour.med.kyoto-u.ac.jp/~molgen/research_summary.html

Title of Project : Investigation on pathological implications of guidance molecules in neuro-immune-metabolism

Atsushi Kumanogoh
(Osaka University, Graduate School of Medicine, Professor)

Research Project Number : 18H05282 Researcher Number : 10294125
Keyword : Immunometabolism, axon guidance molecule, chronic inflammation

【Purpose and Background of the Research】

The immune, nervous, and metabolic systems are indispensable for body homeostasis. Previous studies showed that these systems interact closely with each other. However, the mechanisms underlying these interactions remain unknown. We have unveiled the existence of the semaphorins, a group of molecules that works in both the nervous and immune systems. In addition, we have obtained insights suggesting that the expression of semaphorins and their related molecules is regulated by metabolic signaling, and that breakdown in the regulatory system can result in development of lesions of chronic inflammatory diseases, including angiitis, multiple sclerosis, metabolic diseases and malignancies. By establishing the novel concept of "Neuro-Immune-Metabolism," this research aims to elucidate the mechanism underlying the interactions among the immune, nervous, and metabolic systems (Fig. 1).

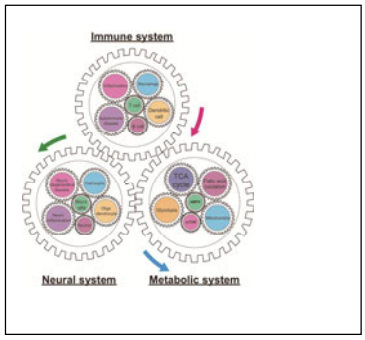


Figure 1

【Research Methods】

Towards elucidation of Neuro-Immune-Metabolism regulatory mechanism and control of the mechanism, this study employs the following viewpoints to achieve the study objective:

1) Elucidation of the mechanism by which immune and inflammatory cells are activated or differentiated by molecules that regulate Neuro-Immune-Metabolism

2) Elucidation of the involvement of abnormal expression of semaphorin-related molecules in disease pathology and the control of semaphorin expression

Additionally, this study proactively integrates basic and clinical approaches ("Bench to Bed" and "Bed to Bench") to pursue the study objectives.

【Expected Research Achievements and Scientific Significance】

Studies that focus on the pairwise relationships between the immune, nervous, and metabolic systems have started to receive a great deal of attention. However, studies that examine the relationships among these three systems from a single perspective have just begun. This research uses the "window" of semaphorins and their related molecules to investigate the relationships among these three systems, with the aim of elucidating the mechanisms underlying their interactions. Based on the novel concept of Neuro-Immune-Metabolism, the resultant knowledge should contribute to development of diagnostic and therapeutic mechanisms for diseases that are caused by any breakdown of the control system (Fig. 2).

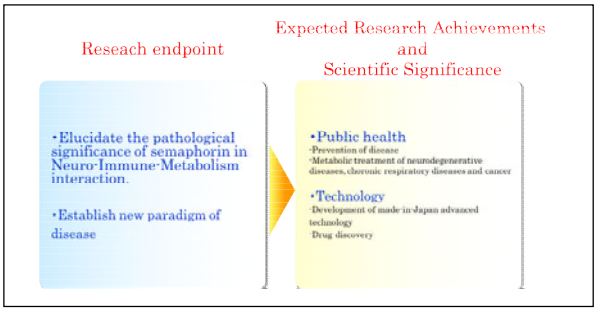


Figure 2

【Publications Relevant to the Project】

・Kang S, Nakanishi Y, Kumanogoh A et al. (2018) Semaphorin 6D reverse signaling controls macrophage lipid metabolism and anti-inflammatory polarization. ***Nature Immunology***, 19, 561-570.

・Hosen N, Kumanogoh A et al. (2017) The activated conformation of integrin β7 is a novel multiple myeloma-specific target for CAR T cell therapy. ***Nature Medicine***, 12, 1436-1443.

【Term of Project】 FY2018-2022

【Budget Allocation】 147,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.imed3.med.osaka-u.ac.jp/

【Grant-in-Aid for Scientific Research (S)】

Broad Section I

Title of Project : Elucidation of the mechanism in the regulation of chondrocyte-specific Runx2 enhancer and development of the drug for osteoarthritis

Toshihisa Komori
(Nagasaki University, Graduate School of Biomedical Sciences, Professor)

Research Project Number : 18H05283 Researcher Number : 00252677
Keyword : chondrocyte, osteoarthritis, enhancer, Runx2

【Purpose and Background of the Research】

We are pursuing to elucidate the mechanism of the formation and maintenance of bone and cartilage focusing on Runx2. We clarified that Runx2 is an essential transcription factor for osteoblast differentiation and chondrocyte maturation, and is responsible for osteoarthritis (Fig. 1, 2). Therefore, Runx2 positively works in adult bone by increasing bone formation and negatively works in articular cartilage by destructing it. The elucidation of the transcriptional regulation of Runx2 in osteoblasts and chondrocytes makes a great advance in the understanding of the molecular mechanism of skeletal development and maintenance. Further, it makes possible to regulate Runx2 in osteoblasts and chondrocytes separately, which allows us to develop the drugs for osteoporosis and osteoarthritis. In this study, we elucidate the

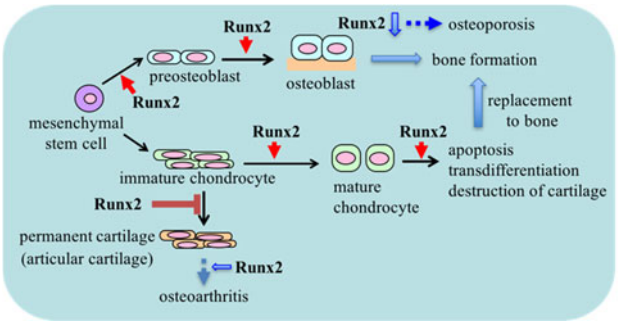


Fig. 1 The functions of Runx2

mechanism of the activation of chondrocyte-specific enhancers and develop the drugs for osteoarthritis using the enhancers.

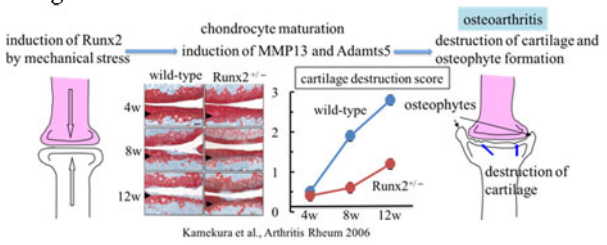


Fig. 2 The development of osteoarthritis by Runx2

【Research Methods】

We clarify the transcription factors and cofactors, which activate chondrocyte-specific Runx2 enhancers, the structure of the enhanceosome, and the interaction of enhancers and promoters. By high throughput screening, we identify the chemical compounds, which inhibit the activity of chondrocyte-specific enhancers and suppress Runx2 expression only in chondrocytes. We evaluate the effect of the selected chemical compounds using osteoarthritis mouse models, identify the molecules interacting with them, and elucidate the mechanisms of action of the selected compounds. From these data, we determine the candidates for the drug for osteoarthritis.

【Expected Research Achievements and Scientific Significance】

More than 25 million people suffer osteoarthritis of knee joints in Japan. Osteoarthritis is caused by the destruction of articular cartilage through the repetitive mechanical stress and its accumulation. It causes disability of walking due to the severe pain. The prosthetic replacement arthroplasty is the only therapy. This is a unique study to develop the drugs for osteoarthritis by using chondrocyte-specific Runx2 enhancers. From this study, we will have the drugs to inhibit the development and progress of osteoarthritis.

【Publications Relevant to the Project】

Komori T: Runx2, an inducer of osteoblast and chondrocyte differentiation. Histochem Cell Biol. 149(4):313-323, 2018.
Kawane T, et. al.: Dlx5 and Mef2 regulate a novel Runx2 enhancer for osteoblast-specific expression. J Bone Miner Res. 29(9):1960-1969, 2014.

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.de.nagasaki-u.ac.jp/dokuji/kaibou-2/index.html

Title of Project : Self-Renewal Capacity of Hematopoietic Stem Cells through the Regulation of Mitochondrial Metabolism

Toshio Suda
(Kumamoto University, International Research Center for Medical Sciences, Distinguished Professor)

Research Project Number : 18H05284 Researcher Number : 60118453
Keyword : Hematopoietic Stem Cells (HSCs), Stem Cell Niche, Mitochondrial Metabolism

【Purpose and Background of the Research】

Ex vivo expansion of HSCs is a long-standing subject in the research field of hematopoiesis, but it has not been realized yet. We hypothesize that HSCs show two types of cell division patterns; self-renewal cell division, which reproduces stem cells, and differentiation division, which produces functioning mature cells.

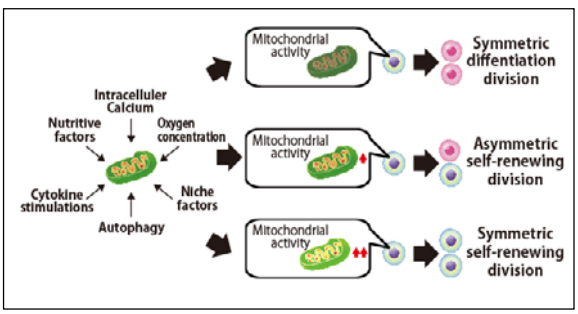
In this project, we will validate how mitochondrial function affects the cell division of HSCs. We have previously shown that oxidative metabolism is critical for the regulation of quiescence and maintenance of HSCs, as well as glycolysis.

Here we will clarify the underlying molecular mechanisms how mitochondria metabolism regulates the stem cell division. We will approach the self-renewal division in HSCs. This project is aiming for the *ex vivo* expansion of HSCs by increasing the self-renewal division by the mitochondrial regulation (see Figure).

【Research Methods】

At first, we will clarify how mitochondrial activation induces the stem cell division and differentiation. We will monitor the mitochondrial mass, membrane potential (MMP) and ROS.

Next, we will clarify how mitochondrial activation is regulated by the HSCs niche. We have previously suggest the following signaling; exogenous adenosine— intracellular Ca^{2+} increase—MMP upregulation—cell division. We will try to connect the missing link in this axis. Especially, to clarify how Ca^{2+} is regulated in HSCs, we will analyze the Ca^{2+} efflux and influx from extracellular compartment and endoplasmic reticulum (ER).



We will analyze the HSC division in MITOL-deficient HSCs, which has abnormalities in mitochondria-ER interaction.

Then, we will examine the quality of mitochondria from the aspect of autophagy/mitophagy. It is interesting to see the regulation of mitochondrial biogenesis and exclusion of damaged mitochondrial in HSCs. We will dissect HSCs of autophagy-defective mice such as ATG7 cKO mice and folliculin (FLCN) cKO mice, in which HSCs are defective. We will analyze the effect of FLCN and downstream signal TFE3 on mitochondria and lysosomal function.

Finally, we challenge to modulate mitochondrial function to increase the self-renewal activity in HSCs and realize the *ex vivo* expansion of HSCs.

【Expected Research Achievements and Scientific Significance】

We will focus on the understanding the mitochondrial function in HSCs. On the basis of these basic data, we will realize the *ex vivo* expansion of HSCs through the mitochondrial modulation.

【Publications Relevant to the Project】

・Ito K, Suda T: Metabolic requirements for the maintenance of self-renewing stem cells. ***Nat Rev Mol Cell Biol*** 141: 243-256, 2014
・Umemoto T, Hashimoto M, Matsumura T, Nakamura-Ishizu A, SudaT: Ca^{2+}-Mitochondrial axis drives cell division in hematopoietic stem cells. ***J Exp Med***, in press. 2018 doi: 10.1084/jem.20180421.

【Term of Project】 FY2018-2022

【Budget Allocation】 140,000 Thousand Yen

【Homepage Address and Other Contact Information】

http:// ircms.kumamoto-u.ac.jp/
sudato@keio.jp

Title of Project : Establishment of a novel strategy for pathological analysis of multifactorial diseases using genetic risk variants

Kazuhiko Yamamoto
(RIKEN, Center for Integrative Medical Sciences, Deputy Director)

Research Project Number : 18H05285 Researcher Number : 80191394
Keyword : multifactorial disease, genome-wide association study, risk variants

【Purpose and Background of the Research】

The purpose of this study is to establish a method for identifying causal intermediate phenotypes in the research of human multifactorial diseases based on the principle that genomic factors clearly indicate causality to disease. Recent findings have indicated that the majority of disease risk variants in multifactorial diseases affect gene expression or splicing. In our study, we will focus on immune diseases. Using genetic information, factors having a causal relationship with diseases will be identified from intermediate phenotypes, such as gene expression, epigenetic changes, protein expression, and cellular alterations, among others. These data will enable the pathogenesis of diseases to be more clearly understood, and facilitate the development of new therapies. Once our method has been established, it could also be applied to multifactorial diseases other than immune diseases.

【Research Methods】

The effects of risk variants, such as single nucleotide polymorphisms (SNP), which are identified in genome-wide association study (GWAS), can be elucidated by combining and analyzing various cellular phenotypes and risk variants. Therefore, we will construct datasets of the relationships between gene expression and genetic variants in subsets of immunocompetent cells. To avoid the influence of diseases or treatments, and to obtain clear causal relationships between the genetic variants and intermediate phenotypes, peripheral blood of healthy individuals will be mainly analyzed. After separating cells into approximately 20 different cell subsets with a cell sorter, gene expression analysis and epigenetic analyses will be carried out. We will then combine and analyze the disease risk variants in each subset according to gene expression, splicing, and epigenetic alternations

【Expected Research Achievements and Scientific Significance】

Many diseases have been studied using animal models, but the differences between humans and these animal models remain a major obstacle for clinical application. With human studies, data can be obtained for some intermediate phenotypes, but the identification of causal factors remains difficult. Data without a demonstrated causal relationship is less useful for subsequent research. Therefore, our system for identifying causal factors of diseases will enable us to gain more information to better understand the exact pathogenesis of diseases for developing new therapies.

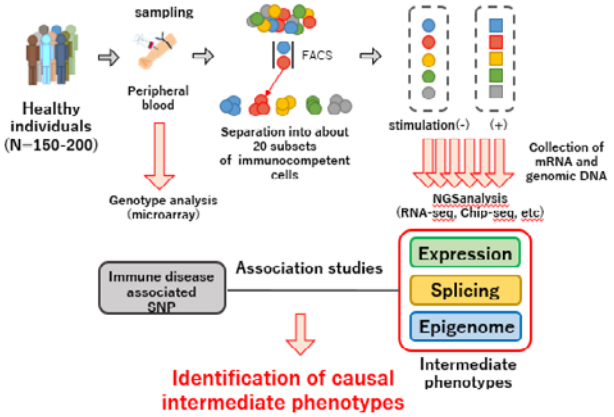


Figure: Novel analysis of multifactorial diseases with risk variants

【Publications Relevant to the Project】

・Ishigaki K, Kochi Y, Suzuki A, et al. and Yamamoto K. Polygenic burdens on cell-specific pathways underlie the risk of rheumatoid arthritis. **Nat Genet**, 2017;49;1120-1125
・Okada Y, Wu D, Trynka G, (+94), Matsuda F, Yamamoto K, and Plenge RM. Genetics of rheumatoid arthritis contributes to biology and drug discovery, et al. **Nature**. 2014; 506:376-81

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.riken.jp/research/labs/ims/autoimmun_dis/

Title of Project : Role of ILC2 in idiopathic interstitial pneumonia

Kazuyo Moro
(RIKEN, Center for Integrative Medical Sciences, Team leader)

Research Project Number : 18H05286　Researcher Number : 90468489
Keyword : Respiratory medicine

【Purpose and Background of the Research】

Idiopathic interstitial pneumonias (IIPs) are a set of diseases that are characterized by progressive deposition of collagen in the pulmonary alveolar interstitium. It has been reported that type 2 immune responses are inappropriately upregulated in the lungs of IIPs patients. However, the etiology of the disease is not fully understood. Group2 innate lymphoid cells (ILC2), which we discovered in 2010 produce large amounts of type 2 cytokines in response to IL-33. IL-33-activated ILC2 have been reported to exacerbate IIPs in the bleomycin-induced mouse model of pulmonary fibrosis. In this project, we will investigate the role of ILC2 in pulmonary fibrosis and verify the pathology of IIPs.

【Research Methods】

The mouse model of bleomycin-induced fibrosis is the most common model used to study IIPs. However, this is a model of acute fibrosis that occurs in 2 weeks and is resolved spontaneously after several weeks. To understand the chronic fibrosis that characterizes idiopathic pulmonary fibrosis (IPF), we have established a new mouse strain which lacks several systems for inhibition of ILC2 and develops pulmonary fibrosis. Unlike conventional models, the fibrosis in this strain occurs spontaneously and worsens in an age-dependent manner. In this project, we will investigate the pathogenic mechanism of IPF by single cell RNA-Sequence analysis, thorough the use of samples from this mouse model of fibrosis and from IPF patients.

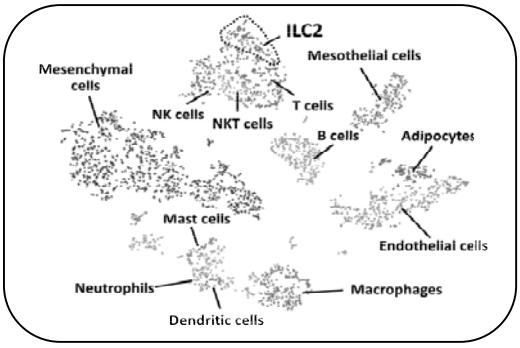


Fig. 1 Single cell RNA-Sequence

【Expected Research Achievements and Scientific Significance】

Find a candidate factors that could be a target for new therapy for IIPs.

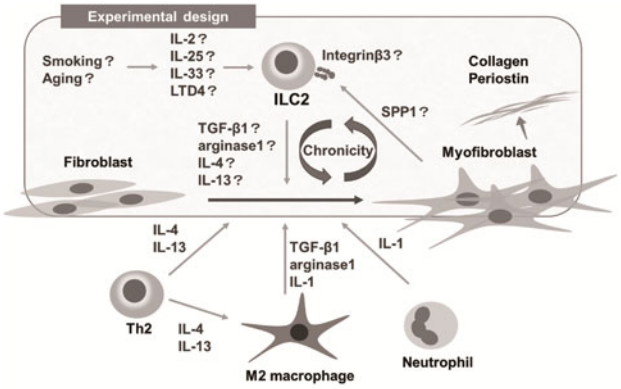


Fig. 2 ILC2 and pulmonary fibrosis

【Publications Relevant to the Project】

・Koga S, Hozumi K, Hirano KI, Yazawa M, Terooatea T. Peripheral PDGFRalpha(+)gp38(+) mesenchymal cells support the differentiation of fetal liver-derived ILC2. (2018)
・Moro K, Kabata H, Tanabe M, Koga S, Takeno N, Mochizuki M, Fukunaga K, Asano K, Betsuyaku T, Koyasu S. Interferon and IL-27 antagonize the function of group 2 innate lymphoid cells and type 2 innate immune responses. Nat Immunol, 17(1): 76-86 (2016)
・Moro K, Yamada T, Tanabe M, Takeuchi T, Ikawa T, Kawamoto H, Furusawa J, Ohtani M, Fujii H, Koyasu S. Innate production of T(H)2 cytokines by adipose tissue-associated c-Kit(+)Sca-1(+) lymphoid cells. Nature, 463(7280): 540-544 (2010)

【Term of Project】 FY2018-2022

【Budget Allocation】 148,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ims.riken.jp/labo/56/index.html

Title of Project : Neural Mechanisms of Functional Recovery via Artificial Neural Connection

Yukio Nishimura
(Tokyo Metropolitan Institute of Medical Science, Department of Dementia and Higher Brain Function, Neural Prosthesis Project, Project Leader)

Research Project Number : 18H05287 Researcher Number : 20390693
Keyword : Artificial Neural Connection, Spinal cord Injury, Functional Recovery

【Purpose and Background of the Research】

Motor impairment in individuals with spinal cord lesion is attributed to the interruption of descending pathways to the spinal circuit, whereas neural circuits below and above the lesion maintain their functional capability. An artificial neural connection (ANC), which bridges supraspinal centers and spinal networks beyond the lesion, may restore the functional impairment. We have shown that ANC enable to compensate for the dysfunction of descending pathways by sending commands to the preserved spinal circuits and enable individuals with paraplegia to regain volitionally controlled paralyzed limb. Individuals may be required to learn a novel causal input-output relationship to control the paralyzed limb. Although, how the brain incorporates a novel "artificial" neural pathway into volitional limb control within the surviving cortical areas remains largely unclear. Using animal model of spinal cord injury (SCI) and SCI patients, the aim of study is elucidate neural mechanisms of adaptation and plasticity in central nervous systems induced by ANC (Fig. 1).

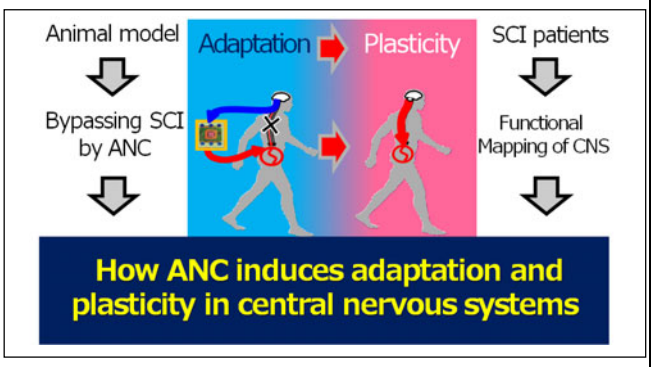


Fig. 1 Research aim

【Research Methods】

We implants multi-channel electrode array in cortical motor area and spinal cord in monkeys. To regain volitional control of the paralyzed hand, the monkeys SCI models are connected to the ANC which bridge cortical motor area and preserved spinal circuits. We investigates neural firing of population cortical cells throughout adaptation process to ANC.

We apply non-invasive ANC in paraplegic humans with chronic SCI to induce functional recovery of voluntary limb control. We investigates cortical and spinal reorganization by MRI and electrophysiological methods.

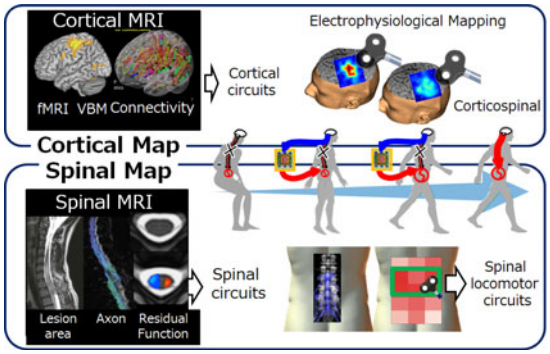


Fig. 2 Functional Mapping

【Expected Research Achievements and Scientific Significance】

The results will show neural mechanisms of functional recovery induced by ANC and propose an innovative neruorehabiliation for SCI

【Publications Relevant to the Project】

・Nishimura Y, Perlmutter SI, Eaton RW, Fetz EE. Spike-timing-dependent plasticity in primate corticospinal connections induced during free behavior. Neuron. 2013;80(5):1301-9.
・Sasada S, Kato K, Kadowaki S, Groiss SJ, Ugawa Y, Komiyama T, Nishimura Y. Volitional walking via upper limb muscle-controlled stimulation of the lumbar locomotor center in man. J Neurosci. 2014 Aug 13;34(33):11131-42.

【Term of Project】 FY2018-2022

【Budget Allocation】 113,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.igakuken.or.jp/project/detail/neuroprosth.html

Title of Project : Innovative Self-Learnable Architecture Platform for Accelerating Intelligent Computing

Masato Motomura
(Hokkaido University, Graduate School of Information Science and Technology, Professor)

Research Project Number : 18H05288 Researcher Number : 90574286
Keyword : Deep Neural Networks, Neuromorphic, Analog and in-Memory Circuits

【Purpose and Background of the Research】

With the advent of deep neural networks (DNNs), AI (Artificial Intelligence) technologies and societal applications are progressing rapidly. To make AI smarter and more energy efficient for realizing future "intelligent computing," not only software but also hardware (HW) technology is essential. To this end, this project brings together newest findings and research progresses in both DNN domain and neuromorphic HW domain, that aims toward more brain-like information processing, for creating an innovative architecture platform for accelerating future intelligent computing.

【Research Methods】

This project will be conducted by Integrated Architecture Research Laboratory and Integrated Nano-Systems Research Laboratory both at the same division of Hokkaido University. The former lab., led by the project leader, has presented binary DNN and log-quantized DNN accelerator HWs and the associated DNN learning methods, that have gained world-wide interests (Fig. 1).

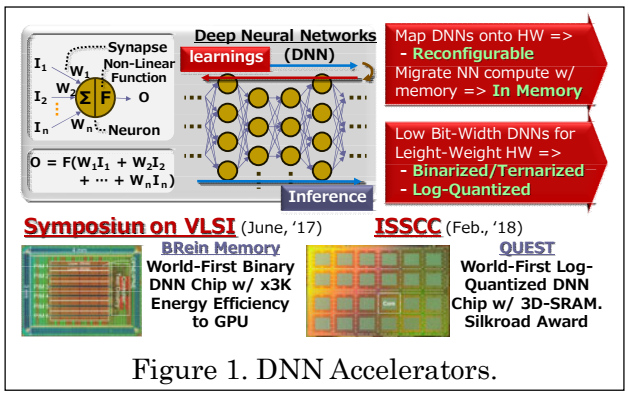


Figure 1. DNN Accelerators.

The latter lab., led by a sub-leader, professor Tetsuya Asai, has been working on analog-circuit oriented neuromorphic HWs (Fig. 2), and reserver computing that is gaining wide interests recently as a new wave in neuromorphic systems. The tight collaboration of these two labs working on related but different subjects is a key differentiation of the research formation at Hokkaido University.

Based on these on-going research activities, this project will try to establish 1) New circuit technologies for reconfigurable HWs for DNNs, 2)

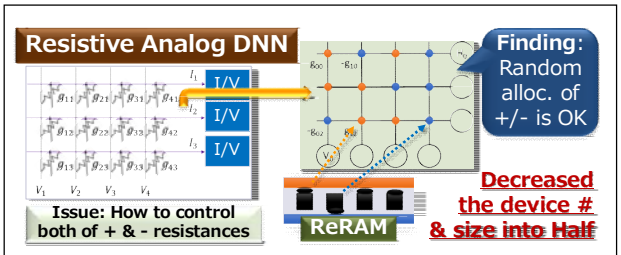


Figure 2. Neuromorphic HW technology.

inter-DNN-Neuromorphic learning systems and the associated HW architectures, 3) algorithm to circuits collaboration on creating high-energy efficiency HWs (including analog and/or in-memory circuit technologies).

【Expected Research Achievements and Scientific Significance】

The project will walk through whole the research chain from algorithmic researches to real HW developments and evaluations. As a final goal, we will try to establish self-learnable reconfigurable HW platforms, on-top of DNN and neuromorphic HWs, for future intelligent computing.

【Publications Relevant to the Project】

- Ando K., et.al., "BRein memory: a 13-layer 4.2 K neuron/0.8M synapse binary/ternary reconfigurable in-memory deep neural network accelerator in 65 nm CMOS," 2017 Symposium on VLSI Circuits [VLSI]. (Jun. 5-8, 2017).
- Ueyoshi K., et.al., "QUEST: a 7.49-TOPS multi-purpose log-quantized DNN inference engine stacked on 96MB 3D SRAM using inductive-coupling technology in 40nm CMOS," IEEE International Solid-State Circuits Conference [ISSCC] (Feb. 12-14, 2018).

【Term of Project】 FY2018-2022

【Budget Allocation】 148,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://lalsie.ist.hokudai.ac.jp/en/

Title of Project : Resilience Enhancement of IoT Ecosystem by Cryptographic Technologies

Kazuo Sakiyama
(The University of Electro-Communications, Graduate School of Informatics and Engineering, Professor)

Research Project Number : 18H05289 Researcher Number : 80508838
Keyword : Information Security, Cryptography, Information Theory, Hardware Security, IC Engineering

【Purpose and Background of the Research】

The purpose of this research is to improve the resilience of the IoT (Internet of Things) systems by considering the circulation of the security state, transited by physical attacks on an IoT device, as the function of IoT ecosystem. Cryptographic devices in the IoT era face the threat of new physical attacks that appear one after another. Laser-based fault attacks are known to be one of the most serious physical attacks against cryptographic IC (Integrated Circuit). If the attacker's ability becomes even higher, we must assume the probing attack that directly reads out intermediate values in IC. In this research, we develop a leakage sensor in order to measure the security state of the key in the cryptographic device, and in each layer of the cryptographic primitive, algorithm, and protocol, we aim to improve the resilience that recovers the IoT system lithely to the normal state even if partial key leakage occurs.

【Research Methods】

We set two specific research topics. The first is the proper introduction of cryptographic technology into IoT systems with physical attack countermeasures in mind. We plan to build a leakage detection technology to check whether the cryptographic key is in a normal condition and leakage-resilient cryptography to withstand key leakage by physical attacks.

The second topic is about the key lifecycle and resilience enhancement of IoT ecosystem. Based on the position that key leakage is inevitable, we consider the expansion of leakage-resilient cryptography that resists physical attacks even if the key leakage is suspected and its collaboration with the key distillation technology that extracts a secure key from a partially-leaked key.

The core technology in this research is cryptography and leakage sensor. In 2019, we design the first leakage sensor applying the optical sensor and the electromagnetic wave sensor and perform the operation verification and the security evaluation. In 2021, we develop a cryptographic device embedded with a leakage sensor and conduct collaborative research on leakage-resilient cryptography, key distillation, and leakage detection technology.

【Expected Research Achievements and Scientific Significance】

We expect to create novel IoT devices with physical attack countermeasures by integrating sensor and cryptographic technology. Theoretical research leads advanced topic such as the construction of a security proof technique incorporating physical parameters and information distillation excluding leaked key information. By combining the results of practical research and theoretical research, we believe that the circulation of the security state of the cryptographic key is achievable as one aspect of the IoT ecosystem.

The leakage sensor developed in this research is a technology that bridges physical and mathematical aspects around detection of the probing attack and can be said to be a new concept enabling a collaboration between different research fields. Namely, this research project functions as a source of academic knowledge creation related to countermeasures against physical attacks.

【Publications Relevant to the Project】

・K. Matsuda, T. Fujii, N. Shoji, T. Sugawara, K. Sakiyama, Y. Hayashi, M. Nagata, N. Miura, “A 286F²/cell Distributed Bulk-Current Sensor and Secure Flush Code Eraser Against Laser Fault Injection Attack,” ISSCC 2018: 352-354 (2018).

・K. Sakiyama, Y. Li, M. Iwamoto, and K. Ohta, “Information-Theoretic Approach to Optimal Differential Fault Analysis,” IEEE Trans. Inf. Forensic Secur., 7(1): 109-120, (2012).

【Term of Project】 FY2018-2022

【Budget Allocation】 149,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://sakiyama-lab.jp/study

Title of Project : Introduction of general causality to various observations and the innovation for its optimal statistical inference

Masanobu Taniguchi
(Waseda University, Graduate School of Science and Engineering, Professor)

Research Project Number : 18H05290 Researcher Number : 00116625
Keyword : Causality, Statistical Optimal Inference, Time-spatial data, Topological data, Medical Image

【Purpose and Background of the Research】

Professor Granger, a Nobel laureate, introduced a causality for two econometric time series. Granger causality has been applied to graph, network, gene, and epidemiology etc.

In this research we will introduce a very general causality, which is applicable to a variety of data, and detects a new hidden factor. The observations are diverse from the usual data to spatio-time observation, discrete time observation from continuous time models, graph, network, high dimensional observation, topological data, gene sequence etc.

The theme of this research to develop the optimal statistical inference for the generalized causality, and applications of the theoretical results to detect a new hidden factor from a variety of fields.

We also deal with a lot of statistical methods, e.g., empirical likelihood, estimation of
circular distribution, distribution on manifolds etc.

This will contribute a prediction, factor analysis, control of risk in various phenomena.

【Research Methods】

To develop our research, Taniguchi (Waseda University) will arrange seminars, workshops at Waseda University to exchange researches, and matching related coworks.

Figure 1 (Road map)

Waseda group will introduce a very general causality, and develop the statistical optimal inference. We apply the theoretical results to analyze medical images to detect a future disease (Figure 2). Aoshima (Tsukuba University) will develop the theory of high-dimensional statistical data, and arrange seminars and workshops on high-dimensional statistical analysis. Yamashita (Institute of Statistical Mathematics) develops the analysis of financial risk by use of the new causal index to detect a hidden factor, and arrange its related workshops at the Institute of Statistical Mathematics.

【Expected Research Achievements and Scientific Significance】

Our new causality is a very general new one which includes the case when the classical causality was not defined, and is applicable to a variety of fields. We will establish the statistical optimal inference to estimate the causality for spatio-time observations, high-dimensional observations, graph & network, topological observations, which opens a new paradigm in causality analysis.

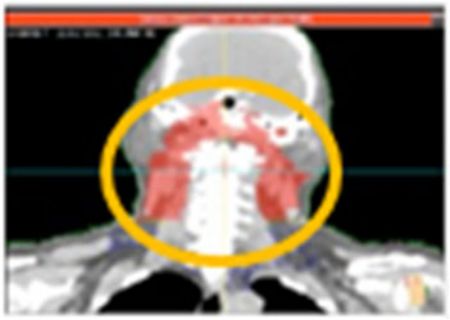


Figure 2 (Medical Image Analysis)1

【Publications Relevant to the Project】

・Granger,C.W.J., Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37 424-439, (1969).
・ Taniguchi,M. and Kakizawa,Y. *Asymptotic Theory of Statistical Inference for Time Series Analysis*, Springer-Verlag, 661pages, (2000).

【Term of Project】 FY2018-2022

【Budget Allocation】 140,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.taniguchi.sci.waseda.ac.jp/kakenhoukoku2018.html.

Title of Project : Large Graphs: Theory and Algorithms

Ken-ichi Kawarabayashi
(Research Organization of Information and Systems, National Institute of Informatics, Principles of Informatics Research Division, Professor)

Research Project Number : 18H05291 Researcher Number : 40361159
Keyword : Graph, Algorithm, Combinatorial Optimization, Theoretical Computer Science

【Purpose and Background of the Research】

Algorithms based on mathematical theory have created progress for human civilization. At present, algorithmic innovations, information searches, and genome information processing are connected to the creation of large business on a national scale. In the 21st century, it is expected that developments in advanced computer science will solve mankind's various problems, but many of these are difficult problems which cannot be solved even if a supercomputer is used. In order to solve these problems, new innovations in algorithms are needed, and new algorithmic technologies which are based on mathematical science have top-priority significance. In particular, the high-speed implementation for large networks and data on the scale of billions of units shall be raised, and will be applied to a wide range of fields, such as transportation, Web analysis and biotechnology. Theoretical research in this proposal could be a breakthrough for solving these global problems.

【Research Methods】

We plan to work on the following three projects.

1. Submodular function appears everywhere in optimization problems and machine learning problems. In this proposal, we attempt to consider the online setting, the adaptive setting, and some robust algorithms.
2. Graph minor theory, by Robertson and Seymour, is perhaps the deepest theory in all of Discrete Mathematics, and it also creates the deepest discrete algorithms. But this theory applies only for undirected graphs. In this proposal, we will extend graph minor theory to digraphs.
3. Graph Coloring is one of the fundamental problems in graph theory and algorithms. In this proposal, we will work on graph coloring problems for planar graphs (i.e., the four color theorem), and graphs on a surface. Our special focus would be to obtain a faster algorithm for these problems.

【Expected Research Achievements and Scientific Significance】

The main point of this proposal is to invent theory-based algorithms for large graphs. In the future, the following academic and technical contributions can be expected from this research proposal.

- With an innovative algorithm based on mathematical analysis, it is possible to solve large-scale graph problems, which is current not possible
- A joint research base of researchers in discrete mathematics, theoretical computer science, probability, combinatorial optimization for solving practical problems through mathematical modeling, can be formulated.

【Publications Relevant to the Project】

K. Kawarabayashi, M. Thorup: Coloring 3-colorable graphs with o(n^{1/5}) colors, Journal of the ACM, 64 Issue 1, Article No 4
K. Kawarabayashi, S. Kreutzer: The Directed Grid Theorem. STOC 2015, 655-664.

【Term of Project】

FY2018-2022

【Budget Allocation】

148,500 Thousand Yen

【Homepage Address and Other Contact Information】

https://bigdata.nii.ac.jp/wp/
k_keniti@nii.ac.jp

Title of Project : Construction of world's most reliable deposited-aerosol database on the Anthropocene (from 1850 to 2020)

Yoshinori Iizuka
(Hokkaido University, Institute of Low Temperature Science, Assistant Professor)

Research Project Number : 18H05292 Researcher Number : 40370043
Keywords : ice core, aerosol, Greenland, high-accumulation area

【Research Purpose and Background】

According to a 2013 IPCC report, anthropogenic contribution factors to global warming are mainly greenhouse gases (warming) and aerosols (cooling). Among these factors, the aerosol-cloud interactions are the least understood scientifically. Thus, enhanced understanding of aerosol-cloud interactions is vital to more precisely evaluating the future prospects of global warming.

One promising approach to evaluating aerosol-cloud interactions is to follow the aphorism, "Discover new things by studying the past." Understanding the past relationships among aerosol concentrations, aerosol-cloud interactions and temperature fluctuations will lead to better forecasts of temperature change.

Aerosols from the past are preserved in snow and ice (cryosphere) through their solid precipitation. A highland in the Greenland ice sheet is an ideal area to evaluate past anthropogenic aerosol trends. In this study, we will drill into the Southeastern Greenland Dome, where aerosols have been extremely well preserved, to obtain a 250-meter-long ice core. Then, we will construct the most reliable database for aerosol concentrations and compositions during the Anthropocene (from 1850 to 2020).

【Research Method】

In our previous project (a study supported by MEXT/JSPS Kakenhi Grant Number 26257201), we obtained a 90-meter-long ice core from the Southeastern Greenland Dome (figure 1), and reconstructed changes in aerosol concentrations and compositions over the most recent 60 years. We found that nitrate aerosols are well-preserved at this site compared to other Greenland sites. In the present research project, we plan to drill a 250-meter-long ice core at the same site in 2020. We will analyze aerosol concentrations of sulfate, nitrate, ammonium, sea salt, dust, black carbon and organic matters, which are often studied for use in aerosol transportation models. Based on the analyzed data, we will construct the world's most reliable deposited-aerosol database on the Anthropocene (from 1850 to 2020). We will apply unique methods that can measure composition and isotopes of aerosol to better understand the mechanisms of aerosol fluctuations and aerosol-cloud interactions.

Figure 1: Ice core drilling at the Southeastern Greenland Dome.

【Expected Research Achievements and Scientific Significance】

The most reliable deposited-aerosol database on the Anthropocene (from 1850 to 2020) will be opened and published for climate model researchers and used as a scenario builder in IPCC reports. By tapping information contained in the database, researchers can provide more reliable forecasts of temperature change. Improved understanding of mechanisms involving aerosol fluctuations and aerosol-cloud interactions is expected to reduce uncertainty in predictions of future climate change.

【Publications Relevant to the Project】

Furukawa et al., Journal of Geophysical Research: Atmospheres, 122, 10,873–10,887, 2017, https://doi.org/10.1002/2017JD026716
Iizuka et al., Journal of Geophysical Research: Atmospheres, 123, 1, 574–589, 2018, https://doi.org/10.1002/2017JD026733

【Project term】 FY2018-2022

【Budget allocation】 147,000 Thousand yen

【Homepage Address and Other Contact Information】

SE-Dome ice core database
https://eprints.lib.hokudai.ac.jp/dspace/handle/2115/67127

【Grant-in-Aid for Scientific Research (S)】

Broad Section K

Title of Project : Environmental electrophiles exposome and reactive sulfur species as its regulator molecule

Yoshito Kumagai
(University of Tsukuba, Faculty of Medicine, Professor)

Research Project Number : 18H05293 Researcher Number : 00250100
Keyword : Electrophiles, Exposome, Redox signaling, Reactive sulfur species, Sulfur adduct

【Purpose and Background of the Research】

We are exposed to a variety of environmental electrophiles (EEs) through food life, life style and life environment on a daily basis. While it has been reported that such reactive species covalently bind to protein nucleophiles, we found that EEs activate redox signaling pathways at lower doses and disrupt these pathways and substantial cytotoxicity at higher doses. It was also found that reactive sulfur species (RSS) negatively regulate modulation of redox signaling and toxicity caused by exposure to EEs, presumably through formation of their sulfur adducts.

Exposome has been defined as the cumulative environmental exposures, including diet, lifestyle, pollutants, and others across the life span; however, the full characterization of the exposome throughout the whole lifespan remains an outstanding challenge. In the current study, we attempt modeling an exposome specialized for EEs with cultured cells and mice in the absence and presence of RSS. We also explore how sulfur adduct derived from methylmercury (MeHg), a model of EEs, undergoes biotransformation by RSS, and then is excreted into out of the body.

【Research Methods】

We perform combined exposure to naphthoquinones, MeHg, cadmium, crotonaldehyde, 1,4-bennzoquinone, acrylamide and/or (*E*)-2-alkenals, and then assess covalent modifications to cellular protein, modulation of 4 different types of redox signaling and toxicity under treatments with and without RSS. We identify unknown metabolites of bismethylmercury sulfide produced from MeHg during interaction with RSS from biological samples of cultured cells and mice given MeHg.

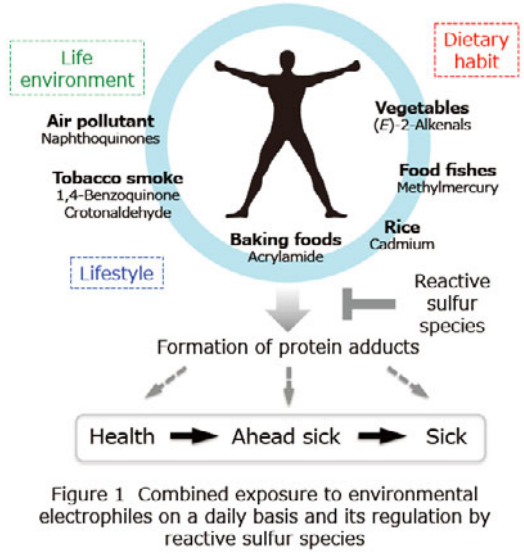


Figure 1 Combined exposure to environmental electrophiles on a daily basis and its regulation by reactive sulfur species

【Expected Research Achievements and Scientific Significance】

We postulate that combined exposure to EEs would lower the threshold for modulation of redox signaling and toxicity negatively regulated by RSS. It was also speculated that RSS plays a role in discharging MeHg into out of body. Therefore, the current study is associated with not only advance in the exposome study for EEs but also a proposal for relief of the health risk caused by EEs.

【Publications Relevant to the Project】

1. Kumagai Y, Abiko Y. Environmental electrophiles: protein adducts, modulation of redox signaling and interaction with persulfides/polysulfides. *Chem Res Toxicol* **30**: 203-219, 2017.
2. Akaike T, Ida T, Fan-Yan Wei FY, Nishida M, Kumagai Y *et al.* Cysteinyl-tRNA synthetase governs cysteine polysulfidation and mitochondrial bioenergetics. *Nature Commun* 8: 1177, 2017.

【Term of Project】 FY2018-2022

【Budget Allocation】 150,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.md.tsukuba.ac.jp/environmental_medicine/index.html
yk-em-tu@md.tsukuba.ac.jp

Title of Project : Study on physics and layers of ice cores containing information of climate change over the past 720 k-years, and study on the "oldest ice"

Shuji Fujita
(Research Organization of Information and Systems, National Institute of Polar Research, Professor)

Research Project Number : 18H05294 Researcher Number : 30250476
Keyword : Antarctica, ice sheet, ice core, climate change, dating, paleo climate

【Purpose and Background of the Research】

Ice cores collected in inland of Antarctica is one of important information sources for histories of climatic changes that occurred over 1.5 M years. At ice core drilling sites, ice is older in deeper layers; such deep layers are subject to vertical compressions by ice flow. In addition, various time-dependent metamorphic processes undergoes by influences of the geothermal heat flux. If such very deep signals are once resolved with high time resolutions, we can uncover the history of rapid climate changes. Such ice-core-based knowledge will be crucial for building strategies to make sustainable society under global warming. However, current state of our knowledge is based on limited and discrete sampling from ice cores. High resolution continuous methods for analysis has just begun in recent years. In this study, we will use cutting-edge methods for high-resolution and continuous measurements for ice cores, based on crystal physics and continuous flow analysis (CFA); we will analyze layers of ice cores spanning ca. 200,000 years and ca. 720,000 years. Based on it, we will (i) produce valuable information of the climate in the past, (ii) clarify nature of the time-dependent metamorphic processes, (iii) synchronize multiple very deep ice cores, and (iv) predict quality of information from ice cores that cover 1.5 M years.

【Research Methods】

At an inland site called Dome Fuji in East Antarctica, ice core researchers organized by the National Institute of Polar Research, Japan, collected ice cores covering 720,000 years. We will analyze portions of the ice cores spanning ca. 200,000 years and ca. 720,000 years. Such very old portion constitute deepest ~1000 m span within the ~3000 m-thick ice sheet. Such layers are subject to vertical compressions. In this study, key questions are as follows:

(i) Can we synchronize these very old portions of ice between to major ice cores drilled at Dome Fuji and Dome C?

(ii) How old age of ice back in time, can we clarify detailed histories of rapid changes of climate?

As actions tackling the questions, we will use two major methods to read the layered strata. One of them is to read layers of crystal textures using a method to measure dielectric permittivity tensor with the millimeter wave resonators. Spatial resolutions of this method is ~20mm. Another method is "Continuous Flow Analysis" (CFA) method to read layers of Si, Na and Ca, with a resolutions of ~10 mm.

【Expected Research Achievements and Scientific Significance】

First, we will produce invaluable ice core data. The data will be used to tackle the key questions. Based on the data, we will synchronize two very old ice cores at Dome Fuji and Dome C, based on collaborations of the European deep ice study community. In addition, we will examine timing difference between the climatic change records between the two ice cores. We aim to accomplish the first reliable and detailed synchronization between very old ice cores up to 720,000 years back in time. we will study change of the climatic mode over the 720,000 years. Furthermore, we will study how very old ice older than 1 M years, can be preserved near the base of the ice sheet.

【Publications Relevant to the Project】

・**Dome Fuji Ice Core Project members** 2017. State dependence of climatic instability over the past 720,000 years from Antarctic ice cores and climate modeling. Sci. Adv. 3(e1600446)
・**Fujita S.** et al. Volcanic synchronization of Dome Fuji and Dome C Antarctic deep ice cores over the past 216 kyr. Clim. Past, 11, 1395-1416, 2015

【Term of Project】 FY2018-2022

【Budget Allocation】 88,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://researchmap.jp/s_fujita/
sfujita@nipr. ac.jp

Title of Project : Methanogenesis from root organic matters in deep subsurface

Yoichi Kamagata
(National Institute of Advanced Industrial Science and Technology (AIST), Bioproduction Research Institute, Senior Researcher)

Research Project Number : 18H05295 Researcher Number : 70356814
Keyword : deep subsurface, methanogenesis, syntrophic network, high pressure cultivation

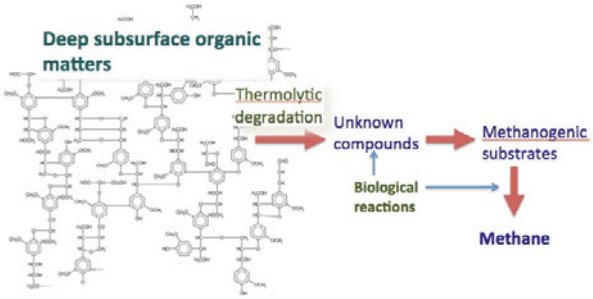
【Purpose and Background of the Research】

Methangenesis occurring in deep subsurface environments involve 1) thermolysis of highly polymeric organic matters present in rocks, coals and oils 2) fermentative degradation of those matters into acetate, methyl compounds, H_2/CO_2, 3) all of which are subsequently converted to methane by methanogenic archaea. However, depending upon *in situ* temperatures and other physico-chemical conditions, the boundary between abiotic and biotic reactions remains largely unknown, thus a whole picture of methanogenesis needs to be clarified to better understand how geochemical and biological process are tightly connected. Questions we raise are 1) what types of chemicals are supplied to microbial communities as a result of thermolytic reactions of organic matters buried in deep subsurface 2) what types of functional microbes including methanogens are associated with bioconversion of organic matters.

【Research Methods】

PI and his collaborators have strong background of geology, geochemistry, microbiology, and genome informatics. In this study, we employ the following approaches. 1) Coals and argillaceous rocks are incubated at high temperatures under high pressure conditions to determine the structures of organic matters released from those rocks by using GC-MS and/or LS-MS. 2) High throughput sequencing technique is applied to comprehensively determine the genomes of microbial communities of deep subsurface biosphere where methanogenesis occurs. RNAseq is also conducted. By combining these methods, we determine what types of fermentative organisms including syntrophs and methanogens are present *in situ* and what functional genes are being expressed under the conditions. Genomes of representative microbes are reconstructed. 3) We cultivate microbes in natural gas-, coal- and oil- associated waters by using a high pressure cultivation apparatus and see what microbes grow and what products are generated using GC-MS and/or LC-MS together with genomic analyses.

【Expected Research Achievements and Scientific Significance】



The hypothesis is that abiotic organic matters and their theymolytic degradation matters sustain the methanogenic biosphere in deep subsurface environments. The hypothesis is already well-known but there have been no direct evidences to support it. Metagenomic research has been focusing solely on community and functional genomics, but has never linked with geochemistry of organic matters buried in deep subsurface. There should be a boundary between abiotic geosphere and biosphere and that boundary may play an important role in transferring organic matters available for microbial community to biosphere. The research outcome would address what types of organic materials are really produced *in situ* and what organisms greatly contribute to methane formation.

【Publications Relevant to the Project】

・Mayumi, D. et al. Methane production from coal by a single methanogen. Science 354: 222-225 (2016).

【Term of Project】

FY2018-2022

【Budget Allocation】

148,800 Thousand Yen

【Homepage Address and Other Contact Information】

https://unit.aist.go.jp/georesenv/geomicrob/member.html
https://unit.aist.go.jp/bpri/bpri-dir/

List of the Continuing Projects for Grant-in-Aid for Scientific Research (S) of KAKENHI

(1) Integrated Disciplines (65 Projects)

○ Informatics (21 Projects)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220001	Teruo Higashino 80173144	Osaka University, Graduate School of Information Science and Technology, Professor	Large-Scale, Tempo-Spatial Information Gathering Mechanism over DTN-enabled Distributed Micro-modules	FY2014-2018	140,000
26220002	Takayuki Aoki 00184036	Tokyo Institute of Technology, Global Scientific Information and Computing Center, Professor	Advancement of CFD Applications for Manufacturing Technology to Exascale	FY2014-2018	144,900
26220003	Masayuki Inaba 50184726	The University of Tokyo, Graduate School of Information Science and Technology, Professor	Acquisition of Body Schema, Tool Usages and Behavioral Manner through Human Observation and Interactive Practice on Various Humanoid Series	FY2014-2018	172,000
26220004	Gentaro Taga 00272477	The University of Tokyo, Graduate School of Education, Professor	Developmental Dynamics of Human Brain from Pattern Formation to Generation of Behaviors	FY2014-2018	150,100
15H05706	Naoki Kobayashi 00262155	The University of Tokyo, Graduate School of Information Science and Technology, Professor	Refinement and Extension of Higher-Order Model Checking	FY2015-2019	149,200
15H05707	Kazuyuki Aihara 40167218	The University of Tokyo, Institute of Industrial Science, Professor	Establishing Theoretical Foundations for Mathematical Modeling of Pathological Biosystems and its Applications to Personalized Medicine	FY2015-2019	148,000
15H05708	Akira Fukuda 80165282	Kyushu University, Graduate School of Information Science and Electrical Engineering, Professor	Research on Information Infrastructure Platform for Sustainable Smart Mobility	FY2015-2019	153,600
15H05709	Masami Tomonaga 70237139	Kyoto University, Primate Research Institute, Associate Professor	Wild Cognitive Science：Comparative–Cognitive Approach toward Understanding Evolution and Diversity of Mind	FY2015-2019	152,700
15H05710	Yukiyasu Kamitani 50418513	Kyoto University, Graduate School of Informatics, Professor	Neural Basis of Mental Images	FY2015-2019	153,700
15H05711	Shinichi Minato 10374612	Kyoto University, Graduate School of Informatics, Professor	Research on Core Algorithms for Discrete Structure Manipulation Systems	FY2015-2019	103,400
16H06299	Shigeyuki Matsui 80305854	Nagoya University, Graduate School of Medicine, Professor	Comprehensive research on statistical methodologies and their applications for development of personalized medicine	FY2016-2020	87,500
16H06300	Takahiro Hanyu 40192702	Tohoku University, Research Institute of Electrical Communication, Professor	Basic Research of a Dark-Silicon-Based Logic-LSI Technology for Brainware Computing	FY2016-2020	127,100
16H06301	Kazuo Fujita 80183101	Kyoto University, Graduate School of Letters, Professor	Acquisition of the independence of mind: Evolution and development of the mind liberated from the current external environments	FY2016-2020	142,900
16H06302	Noboru Babaguchi 30156541	Osaka University, Graduate School of Engineering, Professor	Communication System for Defending against Attacks of Media Clones	FY2016-2020	120,700
16H06303	Hiroyuki Shinoda 40226147	The University of Tokyo, Graduate School of Frontier Sciences, Professor	Systematic Study on Human Response to Noncontact Distributed Haptic Stimulation and Its Applications	FY2016-2020	130,700
16H06304	Hiroaki Ogata 30274260	Kyoto University, Academic Center for Computing and Media Studies, Professor	Educational Cloud Platform for Improving Education and Learning by Using Educational Big Data	FY2016-2020	140,900

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06099	Zhanjiang Hu 50292769	Research Organization of Information and Systems, National Institute of Informatics, Information Systems Architecture Science Research Division, Professor	Software Foundation for Interoperability of Autonomic Distributed Data based on Bidirectional Transformations	FY2017-2021	133,500
17H06100	Seiichi Uchida 70315125	Kyushu University, Faculty of Information Science and Electrical Engineering, Professor	From Text Engineering to Text Science	FY2017-2021	116,000
17H06101	Satoshi Nakamura 30263429	Nara Institute of Science and Technology, Data Science Center, Professor	Next Generation Speech Translation Research	FY2017-2021	157,100
17H06102	Hajime Nagahara 80362648	Osaka University, Institute for Datability Science, Professor	Computational Optical Imaging for Endoscopic Surgery	FY2017-2021	115,800
17H06103	Ken Satoh 00271635	Research Organization of Information and Systems, National Institute of Informatics, Principles of Informatics Research Division, Professor	Advanced Reasoning Support for Judicial Judgment by Artificial Intelligence	FY2017-2021	113,600

○ Environmental Science（ 14 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220101	Fumio Hasebe 00261735	Hokkaido University, Faculty of Environmental Earth Science, Professor	Synthesis of Dynamical and Chemical Descriptions on the Atmospheric Processes in the Tropical Tropopause Layer	FY2014-2018	138,400
26220102	Yukihiro Nojiri 10150161	Hirosaki University, Graduate School of Science and Technology, Professor	Experimental Studies of Ocean Acidification Impact on Coastal Marine Organisms and Ecosystem	FY2014-2018	149,900
26220103	Hisato Iwata 10271652	Ehime University, Center for Marine Environmental Studies, Professor	Multiple Omics Analysis to Understand the Species Difference in Chemical-intracellular Receptor Signaling Disruption	FY2014-2018	150,000
26220104	Kazuyuki Tohji 10175474	Tohoku University, Graduate School of Environmental Studies, Professor	Development of a Low-energy Flat Plane-emission Panel Device Employing Single-walled Carbon Nanotubes	FY2014-2018	147,800
15H05712	Naomi Harada 70344281	Japan Agency for Marine-Earth Science and Technology, Research & Development Center for Global Change, Deputy Director of R&D Center	Plankton in Polar Regions—toward an Understanding of their Characteristics	FY2015-2019	151,900
15H05713	Takeshi Todo 90163948	Osaka University, Institute for Radiation Sciences, Guest Professor	Mechanism of Genome Integrity Maintenance in Tissue Stem Cell	FY2015-2019	153,800
15H05714	Akira Naganuma 80155952	Tohoku University, Graduate School of Pharmaceutical Sciences, Emeritus Professor	Molecular Mechanism for Toxic Effect of Methylmercury	FY2015-2019	151,400
15H05715	Tohru Sekino 20226658	Osaka University, The Institute of Scientific and Industrial Research, Professor	Physical Photochemical Functionalization of Oxide Nanotubes through Hierarchical Structure Tuning	FY2015-2019	153,700
16H06305	Yoshizumi Kajii 40211156	Kyoto University, Graduate School of Global Environmental Studies, Professor	Precise analysis of HOx cycle in the air by novel techniques and new development of oxidants and aerosols chemical dynamics	FY2016-2020	139,600
16H06306	Shunichi Takeda 60188191	Kyoto University, Graduate School of Medicine, Professor	Establishment of Novel Bioassays for in vivo Genotoxicity Prediction and Mechanism Characterization	FY2016-2020	140,900

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
16H06307	Kaoru Sugasawa 70202124	Kobe University, Biosignal Research Center, Professor	Molecular mechanisms underlying higher-order regulation of DNA damage recognition for nucleotide excision repair	FY2016-2020	133,500
16H06308	Hirohisa Takano 60281698	Kyoto University, Graduate School of Global Environmental Studies, Professor	Comprehensive and systematic study for control/eradication of allergic diseases via environmental and medical approaches	FY2016-2020	139,000
17H06104	Ayako Abe-Ouchi 30272537	The University of Tokyo, Atmosphere and Ocean Research Institute, Professor	Understanding the interaction between ice sheets, ocean and atmosphere under large scale climate changes of the past	FY2017-2021	157,600
17H06105	Naohiro Yoshida 60174942	Tokyo Institute of Technology, School of Materials and Chemical Technology, Professor	Environmental diagnosis with isotopologue tracers	FY2017-2021	162,400

○ Complex Systems（ 30 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220201	Shigenobu Shibata 10162629	Waseda University, Faculty of Science and Engineering, Professor	Basic and Applied Studies of Chrononutrition Based on Development of Functional Foods and Nutrients	FY2014-2018	89,900
26220202	Jun Matsumoto 80165894	Tokyo Metropolitan University, Graduate School of Urban Environmental Sciences, Professor	Asian Monsoon Variability during the Past 120 Years	FY2014-2018	148,400
26220203	Keiji Naruse 40252233	Okayama University, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Professor	Mechanomedicine: Application of Mechanobiological Engineering to Regenerative and Reproductive Medicine	FY2014-2018	155,200
26220204	Hiroaki Suga 00361668	The University of Tokyo, Graduate School of Science, Professor	Generation of Minimal Peptide Catalysts Based on the Macrocyclic Scaffold	FY2014-2018	140,000
26220206	Motonari Uesugi 10402926	Kyoto University, Institute for Chemical Research, Professor	Control and Analysis of Cells by Synthetic Small Molecules	FY2014-2018	150,000
15H05716	Toshiyuki Inagaki 60134219	University of Tsukuba, Vice President and Executive Director	Design for Driving Automation and Legal Systems Conforming to Characteristic Features and Limitations of Cognition and/or Decision Making of Human Drivers	FY2015-2019	153,400
15H05717	Gaku Kimura 80153188	Tokyo University of Marine Science and Technology, Project Professor	Urgency Evaluation of the Nankai Great Earthquake and Tsunami by Scientific Ocean Drilling	FY2015-2019	153,500
15H05718	Shuichi Kodaira 80250421	Japan Agency for Marine-Earth Science and Technology, Research & Development Center for Earthquake and Tsunami, Director	Toward Mitigating Tsunami Hazards from Outer-rise Earthquakes: Mapping Potential Earthquake Faults and Constructing a Tsunami Database	FY2015-2019	154,300
15H05719	Michiyasu Suzuki 80196873	Yamaguchi University, Graduate School of Medicine, Professor	Evaluation and Control of Epilepsy Dynamics Based on Multimodal Brain Signals and Thermal Neuromodulation Using Focal Brain Cooling	FY2015-2019	152,600
15H05720	Jun Kataoka 90334507	Waseda University, Faculty of Science and Engineering, Professor	Toward New Frontiers in High-Resolution 3D Color Radiology Imaging	FY2015-2019	112,200
15H05721	Masatoshi Hagiwara 10208423	Kyoto University, Graduate School of Medicine, Professor	Therapeutic Drug Discovery and Elucidation of RNA Disease Pathogenesis by Use of CRISPR-Based Disease iPS Cells and Animal Models	FY2015-2019	153,800
15H05722	Hirohide Saito 20423014	Kyoto University, Center for iPS Cell Research and Application, Professor	Cellular Programming Using Synthetic RNP Nanosystems	FY2015-2019	124,800

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05723	Junichi Nakai 80237198	Saitama University, Graduate School of Science and Engineering, Professor	Development of Fluorescent Probes with Molecular Evolution Engineering	FY2015-2019	154,500
15H05724	Sonoko Ogawa 50396610	University of Tsukuba, Faculty of Human Sciences, Professor	Neuroendocrinology of Social Behavior	FY2015-2019	151,300
16H06309	Hironobu Kan 20294390	Kyushu University, Graduate School of Integrated Sciences for Global Society, Professor	Advanced Interdisciplinary Research on Coastal Areas based on Shallow Seafloor Geomorphology: Development of a Paradigm through 3D Seafloor Mapping	FY2016-2020	126,600
16H06310	Teruyuki Kato 80134633	Hot Springs Research Institute of Kanagawa Prefecture, Others, Director	A challenge to develop GNSS buoy system for high-functional tsunami monitoring and continuous observation of ocean-bottom crustal movements	FY2016-2020	141,900
16H06311	Kazuhisa Tsuboki 90222140	Nagoya University, Institute for Space-Earth Environmental Research, Professor	Dynamical, thermodynamical and cloud-microphysical studies of violent wind and heavy rain-producing tropical cyclones: Quantitative improvement of intensity estimations/forecasts	FY2016-2020	136,600
16H06312	Yuichi Tei (Ung-il Chung) 30345053	The University of Tokyo, Graduate School of Engineering, Professor	Development of “4-dimensional scaffold system” that integrates signaling factors and 3-dimensional structural biomaterials	FY2016-2020	126,600
16H06313	Kazunari Akiyoshi 90201285	Kyoto University, Graduate School of Engineering, Professor	Development of nanogel hybrid materials for medical application	FY2016-2020	133,100
16H06314	Shunichi Kuroda 60263406	Osaka University, The Institute of Scientific and Industrial Research, Professor	Development of Neo-Bionanocapsules: Drug and Gene Delivery System to Wide Range Tissues with Virus-derived Functional Domains	FY2016-2020	139,100
16H06315	Michio Murata 40183652	Osaka University, Graduate School of Science, Professor	Dynamic structure and domain formation of membrane lipids in model bilayer systems	FY2016-2020	140,600
16H06316	Toru Takumi 00222092	RIKEN, Center for Brain Science, Team Leader	Integrative Biology of Autism Spectrum Disorder	FY2016-2020	139,200
16H06317	Hitoshi Okamoto 40183769	RIKEN, Center for Brain Science, Laboratory for Neural Circuit Dynamics of Decision Making, Team Leader	Neural circuit mechanisms controlling social conflicts	FY2016-2020	142,900
17H06107	Hajime Shirouzu 60333168	The University of Tokyo, Center for Research and Development on Transition from Secondary to Higher Education, Professor	Renovating Assessment for the Future: Design-Based Implementation Research for a Learning-in-Class Monitoring System Based on the Learning Sciences	FY2017-2021	154,500
17H06108	Shunichi Koshimura 50360847	Tohoku University, International Research Institute of Disaster Science, Professor	Fusion of sensing and simulation of tsunami damage assessment towards innovation of disaster medical system	FY2017-2021	156,900
17H06109	Takanori Yokota 90231688	Tokyo Medical and Dental University, Graduate School of Medical and Dental Sciences, Professor	Development of heteroduplex oligonucleotide crossing the blood-brain barrier	FY2017-2021	133,100
17H06110	Masayuki Inoue 70322998	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	Expanding the medicinally relevant chemical space with architecturally complex natural products and their synthetic analogues	FY2017-2021	157,800
17H06111	Mikiko C. Siomi 20322745	The University of Tokyo, Graduate School of Science, Professor	Comprehensive understanding of molecular mechanism underlying the piRNA pathway	FY2017-2021	155,800
17H06112	Hiroshi Handa 80107432	Tokyo Medical University, Department of Nanoparticle Translational Research, Professor	Search for novel modulators of cereblon, the target of thalidomide that regulates neural stem cell proliferation and differentiation	FY2017-2019	139,300
17H06113	Yuichi Iino 40192471	The University of Tokyo, Graduate School of Science, Professor	Dissection of molecules and neural circuits underlying a behavioral switch	FY2017-2021	156,800

(2) Humanities and Social Sciences (24 Projects)

○ Humanities (11 Projects)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220401	Yasurō Abe 60193009	Nagoya University, Graduate School of Letters, Professor	An Exploration and Comprehensive Study of the Heritage of Religious Texts: Building a Humanities Archives Network	FY2014-2018	139,300
26220402	Toru Hoya 60195518	The University of Tokyo, Historiographical Institute, Professor	Researching the Collection and Utilization of Overseas Japan-related Sources through Multi-archival Methods	FY2014-2018	158,200
26220403	Hiroshi Okumura 60185551	Kobe University, Graduate School of Humanities, Professor	Establishment of Local History Materials Science: Forming Disaster Subculture in the Post-3·11 World	FY2014-2018	86,800
15H05725	Masahiro Shimoda 50272448	The University of Tokyo, Graduate School of Humanities and Sociology, Professor	Construction of a New Knowledge Base for Buddhist Studies: Presentation of an Advanced Model for the Next Generation of Humanities Research	FY2015-2018	47,600
16H06319	Reiko Mazuka 00392126	RIKEN, Center for Brain Science, Team Leader	Seeking the onset of infant speech development: An explanation of developmental mechanisms from the perspective of Asian languages	FY2016-2020	87,200
16H06320	Yasuko Takezawa 70227015	Kyoto University, Institute for Research in Humanities, Professor	Integrated Research into the Processes and Mechanisms of Racialization	FY2016-2020	116,100
17H06114	Yuji Nagashima 50138137	Kogakuin University, Faculty of Informatics, Professor	Research into Constructing a Japanese Sign Language Multi-Dimensional Database	FY2017-2020	109,200
17H06115	Shigehisa Karimata 50224712	University of the Ryukyus, Research Institute for Islands and Sustainability, Professor	Comparative historical research on Ryukyuan by using linguistic family trees	FY2017-2021	135,600
17H06116	Tomoko Shiroyama 60281763	The University of Tokyo, Graduate School of Economics, Professor	The Hydrosphere and Socioeconomics in Modern Asia - Exploring a New Regional History Using a Database and Spatial Analysis	FY2017-2021	140,800
17H06117	Isao Tajima 80292796	The University of Tokyo, Historiographical Institute, Professor	Advancing Japanese Bibliographics and Improving the Accessibility of Documents Held by Royal and Aristocratic Archives - Clarifying the Structure and Transmission of Knowledge Systems	FY2017-2021	157,000
17H06118	Takeshi Nakatsuka 60242880	National Institutes for the Humanities, Research Institute for Humanity and Nature, Research Department, Professor	Reorganization of prehistorical structure of calendar age and evaluation of climate change effect in Japanese archipelago using tree ring oxygen isotope ratios	FY2017-2021	160,000

○ Social Sciences (13 Projects)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220501	Noriko Okubo 00261826	Osaka University, Graduate School of Law and Politics, Professor	Review of Legal Indicators for the Participation Principle in Environmental Matters: - Promotion of an International Cooperation towards Strengthening the Environmental Democracy	FY2014-2018	57,400
26220502	Yasuyuki Sawada 40322078	The University of Tokyo, Graduate School of Economics, Professor	Risk and Well-Being Under Changing Global Society: Empirical Policy Research Based on Advanced Micro-Econometrics	FY2014-2018	150,200
26220503	Jota Ishikawa 80240761	Hitotsubashi University, Graduate School of Economics, Professor	Diverse Risk Assessment in the Global Economy from the Viewpoint of International Economics	FY2014-2018	150,000
15H05726	Hajime Wada 30158703	Nagoya University, Graduate School of Law, Professor	Employment Sustainability and the Shifting Paradigm of Labor Law	FY2015-2019	76,000

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05727	Mikitaka Masuyama 50317616	National Graduate Institute for Policy Studies, School of Policy Studies, Professor	An Analytical and Practical Approach to Universal and International Access to Policy Information	FY2015-2019	139,900
15H05728	Yoshiyasu Ono 70130763	Osaka University, Institute of Social and Economic Research, Specially Appointed Professor	Behavioral-Economic Analysis of Long-Run Stagnation	FY2015-2019	153,600
15H05729	Takashi Kamihigashi 30324908	Kobe University, Center for Computational Social Science, Professor	Risk Management of Comprehensive Monetary/Fiscal Policy: Theory, Empirics, and Simulations	FY2015-2019	141,400
16H06318	Motoji Matsuda 50173852	Kyoto University, Graduate School of Letters, Professor	"African Potential" and overcoming the difficulties of modern world: comprehensive area studies that will provide a new perspective for the future of humanity	FY2016-2020	140,000
16H06321	Iwao Sato 80154037	The University of Tokyo, Institute of Social Science, Professor	Research on Disputing Behavior and Judicial Policy in the Super-Aging Society	FY2016-2020	127,700
16H06322	Kyoji Fukao 30173305	Hitotsubashi University, Institute of Economic Research, Professor	Service Sector Productivity in Japan: Determinants and Policies	FY2016-2020	98,900
16H06323	Hideo Akabayashi 90296731	Keio University, Faculty of Economics, Professor	Investigation of the long-term causal effect of economic inequality on educational inequality based on longitudinal survey and experiments of parent-child pairs and international comparison	FY2016-2020	140,400
16H06324	Tatsuya Kameda 20214554	The University of Tokyo, Graduate School of Humanities and Sociology, Professor	Understanding of cognitive, neural and ecological bases of human collective behavior	FY2016-2020	140,500
16H06325	Kaoru Sekiyama 70216539	Kyoto University, Graduate School of Advanced Integrated Studies in Human Survivability, Professor	Lifestyle and Brain Function: Inquiry in Psychological Science into Successful Aging	FY2016-2020	101,800

(3) Science and Engineering (164 Projects)

○ Interdisciplinary Science and Engineering (30 Projects)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220601	Yasunobu Nakamura 90524083	The University of Tokyo, Research Center for Advanced Science and Technology, Professor	Hybrid Quantum Systems Using Collective Modes in Solids with Broken Symmetry	FY2014-2018	150,100
26220602	Kohei M. Itoh 30276414	Keio University, Faculty of Science and Technology, Professor	Diamond Quantum Sensing	FY2014-2018	165,200
26220603	Masateru Taniguchi 40362628	Osaka University, The Institute of Scientific and Industrial Research, Professor	Single-Molecule Sequencing Methods via Tunneling Current	FY2014-2018	136,700
26220604	Kazuya Ando 30579610	Keio University, Faculty of Science and Technology, Associate Professor	Spin Hall Nanoelectronics	FY2014-2018	150,000
26220605	Shigeaki Zaima 70158947	Nagoya University, Institute of Innovation for Future Society, Professor	Establishment of Fundamental Engineering of Sn-related Group-IV Semiconductor Materials for Multi-Functional and Low-Power Electronics	FY2014-2018	138,600
26220606	Katsumi Midorikawa 40166070	RIKEN, Center for Advanced Photonics, Director	Generation of Intense Isolated Attosecond Pulses and their Application to Attosecond Electron Dynamics Measurement	FY2014-2018	134,400

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220607	Toshiyuki Azuma 70212529	RIKEN, Cluster for Pioneering Research, Chief Scientist	Interdisciplinary Science Explored by Cryogenic Electrostatic Ion Storage Ring: from Astrochemistry to Radiation Biology	FY2014-2018	147,000
15H05731	Yuki Kimura 50449542	Hokkaido University, Institute of Low Temperature Science, Associate Professor	Nucleation	FY2015-2019	134,100
15H05732	Yoichi Kawakami 30214604	Kyoto University, Graduate School of Engineering, Professor	Achievement of Tailor-made Lighting Sources by the Control of Nanoscopic Carrier Localization in Nitride Semiconductors	FY2015-2019	146,300
15H05733	Hideki Hirayama 70270593	RIKEN, Cluster for Pioneering Research, Quantum Optodevice Laboratory, Chief Scientist	Research on Unexplored Frequency Quantum-Cascade Lasers Using Nitride Semiconductors	FY2015-2019	154,500
15H05735	Masaya Notomi 50393799	Tokyo Institute of Technology, School of Science, Department of Physics, Professor	Novel Photonic Integration Platform with Hybrid Nanophotonics-Nanomaterials Systems	FY2015-2019	142,600
15H05736	Satoshi Hamaguchi 60301826	Osaka University, Graduate School of Engineering, Professor	Quantum Theoretical Analyses of Plasma Processing for Novel and Diverse Materials Using Multi-Scale Numerical Simulations	FY2015-2019	116,900
15H05737	Yoshinori Nishino 40392063	Hokkaido University, Research Institute for Electronic Science, Professor	Cell Dynamics Studied by X-Ray Laser Diffraction	FY2015-2019	153,900
16H06326	Hideo Kosaka 20361199	Yokohama National University, Faculty of Engineering, Professor	Research for quantum media conversion in diamond nano quantum system	FY2016-2020	138,900
16H06327	Yasuhiro Sugawara 40206404	Osaka University, Graduate School of Engineering, Professor	Assembly of nanostructure on insulating surfaces and investigation of gas reaction mechanism using atomic force microscopy	FY2016-2020	139,100
16H06328	Teruo Fujii 30251474	The University of Tokyo, Institute of Industrial Science, Professor	Microfluidic approach to single cell transcriptome analysis and its applications	FY2016-2020	136,600
16H06329	Shoji Takeuchi 90343110	The University of Tokyo, Institute of Industrial Science, Professor	Establishment of Cell Fiber Engineering For Next Generation of 3D Tissue Culture	FY2016-2020	144,900
16H06330	Masashi Shiraishi 30397682	Kyoto University, Graduate School of Engineering, Professor	Semiconductor Spin-currentronics	FY2016-2020	134,400
16H06331	Kazunari Matsuda 40311435	Kyoto University, Institute of Advanced Energy, Professor	Development and application of valley-spin photonics in atomically thin layered materials	FY2016-2020	142,800
16H06332	Seiji Mitani 20250813	National Institute for Materials Science, Research Center for Magnetic and Spintronic Materials, Deputy Director	Microscopic understanding of interface spin-orbit coupling and development of perpendicular magnetic anisotropy devices	FY2016-2020	145,000
16H06333	Kazutomo Suenaga 00357253	National Institute of Advanced Industrial Science and Technology, Nano-Materials Research Institute, Prime Senior Researcher	Advanced Single-Atom Spectroscopy	FY2016-2020	130,900
16H06334	Toshihiko Baba 50202271	Yokohama National University, Graduate School of Engineering, Professor	High-performance nanolaser biosensor with an ion-sensitivity	FY2016-2020	130,400
17H06119	Yasujiro Murata 40314273	Kyoto University, Institute for Chemical Research, Professor	Creation and Development of Nanoscale Laboratory	FY2017-2021	160,100
17H06120	Akira Oiwa 10321902	Osaka University, The Institute of Scientific and Industrial Research, Professor	Interconversion of Quantum States Between Photon and Electron Spin Using Electrically Controlled Quantum Dots	FY2017-2021	166,100

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06121	Toshio Ando 50184320	Kanazawa University, Nano Life Science Institute (WPI-NanoLSI), Professor	Realization of nano-dynamics imaging of protein molecules in extremely soft membrane environments	FY2017-2021	126,400
17H06122	Hirofumi Yamada 40283626	Kyoto University, Graduate School of Engineering, Professor	Direct visualization of molecular recognition forces by high-resolution atomic force microscopy and spectroscopy	FY2017-2021	141,900
17H06123	Junichi Takeya 20371289	The University of Tokyo, Graduate School of Frontier Sciences, Professor	Giant strain effect of charge transport in organic single-crystal semiconductors and flexible mechano-electronics	FY2017-2021	163,300
17H06124	Koichiro Tanaka 90212034	Kyoto University, Graduate School of Science, Professor	New development of nonlinear photoelectronics based on terahertz strong field physics	FY2017-2021	162,300
17H06125	Susumu Noda 10208358	Kyoto University, Graduate School of Engineering, Professor	Spectral control of near-field thermal radiation for highly efficient thermo-photovoltaic power generation	FY2017-2021	154,900
17H06126	Yasuhiro Miyake 80209882	High Energy Accelerator Research Organization, Institute of Materials Structure Science, Professor	Transmission Muon Microscope by muon microbeam, realizing 3-D Imaging	FY2017-2021	159,300

○ Mathematical and Physical Sciences（ 55 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220701	Takayuki Hibi 80181113	Osaka University, Graduate School of Information Science and Technology, Professor	The Birth of Modern Trends on Commutative Algebra and Convex Polytopes with Statistical and Computational Strategies	FY2014-2018	137,700
26220702	Yoshikazu Giga 70144110	The University of Tokyo, Graduate School of Mathematical Sciences, Professor	Advanced Analysis on Evolving Patterns in Nonlinear Phenomena Driven by Singular Structure	FY2014-2018	119,800
26220703	Takaya Ohashi 70183027	Tokyo Metropolitan University, Graduate School of Science, Professor	Study of Large-scale Cosmic Plasmas by Wide-field X-ray Spectroscopy Observations	FY2014-2018	158,500
26220704	Guyon Olivier 90399288	National Institute of Natural Sciences, National Astronomical Observatory of Japan, RCUH Staff	Imaging Habitable Zone Planets with Subaru Telescope and TMT	FY2014-2018	117,200
26220705	Yasuhiro Sakemi 90251602	The University of Tokyo, Graduate school of Science, Professor	Search for the Electric Dipole Moment with Laser Cooled Radioactive Atoms in the Optical Lattice	FY2014-2018	149,700
26220707	Toru Sugitate 80144806	Hiroshima University, Graduate School of Science, Professor	Photon Physics Revealing Hidden Properties of Quark Matter in the ALICE Experiment	FY2014-2018	141,200
26220708	Shoji Torii 90167536	Waseda University, Faculty of Science and Engineering, Professor	Research on the Acceleration and Propagation of Cosmic Rays by High-precision Direct Observation	FY2014-2018	130,000
26220709	Masashi Hazumi 20263197	High Energy Accelerator Research Organization, Institute of Particle and Nuclear Studies, Professor	Physical Cosmology with POLARBEAR-2: a New Instrument for the Cosmic Microwave Background Polarization Measurements	FY2014-2018	158,300
26220710	Seigo Tarucha 40302799	The University of Tokyo, Graduate School of Engineering, Professor	Exploring the Novel Quantum Electronic Physics in Solid State Using Spatial Control of Paired Quantum States	FY2014-2018	150,000
26220711	Kensuke Kobayashi 10302803	Osaka University, Graduate School of Science, Professor	Microscopic Understanding and Control of Nonequilibrium Spin Transport in Mesoscopic Systems	FY2014-2018	149,600

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220712	Shigeki Takeuchi 80321959	Kyoto University, Graduate School of Engineering, Professor	Realization and Application of Large-scale Quantum Entangled States Using Photonic Quantum Circuits	FY2014-2018	146,300
26220713	Tsuyoshi Komiya 30361786	The University of Tokyo, Graduate School of Arts and Sciences, Associate Professor	Decoding of the Early Earth's Evolution	FY2014-2018	149,800
15H05738	Shigeyuki Kondo 50186847	Nagoya University, Graduate School of Mathematics, Professor	Lattices, Automorphic Forms and Moduli Spaces	FY2015-2019	68,400
15H05739	Koji Fujiwara 60229078	Kyoto University, Graduate School of Science, Professor	Geometric Group Theory	FY2015-2019	60,800
15H05740	Masahiro Yamamoto 50182647	The University of Tokyo, Graduate School of Mathematical Sciences, Professor	Renovating Solutions and Applications of Coefficient Inverse Problems for Partial Differential Equations	FY2015-2019	140,000
15H05741	Shoichi Ogio 20242258	Osaka City University, Graduate School of Science, Professor	Study of the Ultra High Energy Cosmic Ray Source Evolution by Detailed Measurement of Cosmic Rays in the Wide Energy Range	FY2015-2019	124,900
15H05742	Naohito Saito 20321763	High Energy Accelerator Research Organization, J-PARC Center, Director	Sensitive Search for New Physics Law with Precision Measurement of Muon Anomalous Magnetic Moment	FY2015-2019	155,700
15H05743	Chiko Otani 50281663	RIKEN, Center for Advanced Photonics, Team Leader	Investigation of Inflation Cosmology with Ground-based Experiment of Large-angle Distribution of CMB B-mode Polarization	FY2015-2019	153,200
15H05744	Shuji Matsuura 10321572	Kwansei Gakuin University, School of Science and Technology, Professor	Probing into the Intra-Halo Light and the Epoch of Cosmic Re-Ionization by Rocket Experiments to Measure the Cosmic Infrared Background	FY2015-2019	100,000
15H05745	Kenji Ishida 90243196	Kyoto University, Graduate School of Science, Professor	Understanding of the Superconducting Mechanism and Search for a Novel Superconducting State in Uranium Heavy-Fermion Compounds	FY2015-2019	153,800
15H05746	Kunihiko Kaneko 30177513	The University of Tokyo, Graduate School of Arts and Sciences, Professor	Macroscopic Theory for Robustness and Plasticity in Cells	FY2015-2019	140,400
15H05747	Ryoichi Fujii 00132712	Nagoya University, Institute for Space-Earth Environmental Research, Emeritus Professor	The Quest for the Ultimate Production Mechanism of Pulsating Auroras with Extremely High Time Resolution and Coordinated Observations from Space and Ground	FY2015-2019	152,600
15H05748	Eiji Ohtani 60136306	Tohoku University, Graduate School of Science, Fellow	Creation of the Best Model of the Earth's Core	FY2015-2019	149,700
15H05749	Hiroshi Naraoka 20198386	Kyushu University, Faculty of Science, Professor	Advanced Trace Organic Compound Study in Planetary Materials: Development of High Sensitivity and High Resolution	FY2015-2019	154,800
15H05750	Yasushi Ono 30214191	The University of Tokyo, Graduate School of Frontier Sciences, Professor	2D Imaging Study of High Power Heating / Acceleration of High Magnetic Field Reconnection for its Physics and Application	FY2015-2019	153,900
15H05751	Kazuo A. Tanaka 70171741	Osaka University, Open and Transdisciplinary Research Initiatives, Professor	Proof of Fast Ignition Scheme Using Super-penetration of Laser Light	FY2015-2019	145,000
16H06335	Atsushi Moriwaki 70191062	Kyoto University, Graduate School of Science, Professor	New development of algebraic geometry viewed from theoretical physics	FY2016-2020	61,700
16H06336	Masanobu Kaneko 70202017	Kyushu University, Faculty of Mathematics, Professor	Multiple Zeta Values and Functions	FY2016-2020	75,400

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
16H06337	Atsushi Takahashi 50314290	Osaka University, Graduate School of Science, Professor	Fusion of Birational Geometry and Theory of Periods; A New Era for Studies of Mirror Symmetry	FY2016-2020	79,900
16H06338	Hirofumi Osada 20177207	Kyushu University, Graduate School of Mathematics, Professor	Stochastic Analysis on Infinite Particle Systems	FY2016-2020	90,100
16H06339	Hideo Kozono 00195728	Waseda University, Faculty of Science and Engineering, Professor	New development of mathematical theory of turbulence by collaboration of the nonlinear analysis and computational fluid dynamics	FY2016-2020	123,600
16H06340	Toshimi Suda 30202138	Tohoku University, Research Center for Electron-Photon Science, Professor	Precise determination of the proton charge radius by electron scattering off proton at ultra-low momentum transfer region	FY2016-2020	128,500
16H06341	Toshikazu Shigeyama 70211951	The University of Tokyo, Graduate School of Science, Associate Professor	Study of binary neutron star merger by high cadence optical observations	FY2016-2020	98,300
16H06342	Daisuke Yonetoku 40345608	Kanazawa University, College of Science and Engineering, Professor	Identification of Gravitational Wave Sources with X-ray Transient Monitor and Study of Black Hole Formation Mechanism	FY2016-2020	140,800
16H06343	Taku Yamanaka 20243157	Osaka University, Graduate School of Science, Professor	Search for new physics in rare kaon decays	FY2016-2020	133,800
16H06344	Takasumi Maruyama 80375401	High Energy Accelerator Research Organization, Institute of Particle and Nuclear Studies, Associate Professor	Searching for a sterile neutrino at J-PARC MLF	FY2016-2020	140,100
16H06345	Masatoshi Imada 70143542	The University of Tokyo, Graduate School of Engineering, Professor	Materials Design and Exploration of Functions for Strongly Correlated Materials – Challenges to Non-Equilibrium and Non-Periodic Systems	FY2016-2020	85,400
16H06346	Reizo Kato 80169531	RIKEN, Cluster for Pioneering Research, (Condensed Molecular Materials Laboratory), Chief Scientist	Molecular quantum liquids in strongly correlated electron systems	FY2016-2020	142,600
16H06347	Katsuyoshi Michibayashi 20270978	Nagoya University, Graduate School of Environmental Studies, Professor	Physical properties of uppermost mantle structure and the Mohorovicic seismic discontinuity	FY2016-2020	141,700
16H06348	Michihiko Nakamura 70260528	Tohoku University, Graduate School of Science, Professor	Development of near-real-time volcanology based on in-situ observation experiments of shallow magmatic processe	FY2016-2020	136,100
16H06349	Hisayoshi Yurimoto 80191485	Hokkaido University, Faculty of Science, Professor	Physicochemical analysis of early solar system based on formation kinetics of refractory inclusions of meteorites	FY2016-2020	140,700
17H06127	Masa-Hiko Saito 80183044	Kobe University, Center for Mathematical and Data Sciences, Professor	Algebraic Geometry and Integrable Systems - Deepning of Theory and New Developments in Mathematics and Mathematical Physics -	FY2017-2021	92,000
17H06128	Osamu Saeki 30201510	Kyushu University, Institute of Mathematics for Industry, Professor	Innovative Research of Geometric Topology and Singularities of Differentiable Mappings	FY2017-2021	62,800
17H06129	Masayuki Akiyama 50425401	Tohoku University, Astronomical Institute, Professor	Establishing processes of galaxy structure revealed by a Subaru tomographic adaptive optics	FY2017-2021	161,300
17H06130	Kotaro Kohno 80321587	The University of Tokyo, Graduate School of Science, Professor	Study of cosmic star-formation history based on an unbiased survey of millimeter- and submillimeter-wave emission-line galaxies	FY2017-2021	163,700
17H06131	Masahiro Teshima 40197778	The University of Tokyo, Institute for Cosmic Ray Research, Professor	Study of the Extreme Universe with the CTA Large Size Telescopes	FY2017-2021	157,100

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06132	Shigeki Aoki 80211689	Kobe University, Graduate School of Human Development and Environment, Professor	Cosmic gamma-ray observation by balloon borne emulsion telescope to study unsolved issues	FY2017-2021	153,900
17H06133	Nobuyuki Kanda 50251484	Osaka City University, Graduate School of Science, Professor	Calibration Standard and High-Precision Data Analysis toward the Observational Era of Gravitational Waves	FY2017-2021	139,600
17H06134	Osamu Tajima 80391704	Kyoto University, Graduate School of Science, Associate Professor	Quest for the origin of the Big-Bang and measurements of sum of the neutrino masses by using the world's largest CMB telescope array	FY2017-2021	161,100
17H06135	Satoshi Mihara 80292837	High Energy Accelerator Research Organization, Institute of Particle and Nuclear Studies, Professor	Study on the charged lepton flavor mixing using the high-intensity pulsed muon beam	FY2017-2021	152,000
17H06136	Yoshiteru Maeno 80181600	Kyoto University, Graduate School of Science, Professor	DC Electric Field and Current: Novel Control Parameters for Strongly Correlated Electron Systems	FY2017-2021	159,000
17H06137	Hikaru Kawamura 30153018	Osaka University, Graduate School of Science, Professor	Frustration-induced spin textures	FY2017-2021	165,300
17H06138	Yasuhiro Hatsugai 80218495	University of Tsukuba, Division of Physics, Professor	Variety and universality of bulk-edge correspondence in topological phases: From solid state physics to transdisciplinary concepts	FY2017-2021	157,800
17H06139	Hajime Okamoto 10333783	Kyushu University, Research Institute for Applied Mechanics, Professor	Analysis of cloud microphysics and vertical velocity by synergy use of next generation space-borne active sensors	FY2017-2021	147,900
17H06140	Yoshiharu Omura 50177002	Kyoto University, Research Institute for Sustainable Humanosphere, Professor	Analyses and Verification of Particle Acceleration and Scattering by Electromagnetic Cyclotron Waves in Space Plasmas	FY2017-2021	133,700

○ Chemistry（25 Projects）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220801	Hiroshi Nishihara 70156090	The University of Tokyo, Graduate School of Science, Professor	Synthesis of Functional Nanostructures by Interfacial Coordination Programming and Creation of Chemical Devices	FY2014-2018	150,100
26220802	Zhaomin Hou 10261158	RIKEN, Cluster for Pioneering Research, Chief Scientist	Development of New Catalysts Based on Half-Sandwich Metal Complex Structures	FY2014-2018	149,900
26220803	Keiji Maruoka 20135304	Kyoto University, Graduate School of Science, Professor	Design of Next-Generation Organocatalysts for the Application to Practical, Fine Organic Synthesis	FY2014-2018	150,000
26220804	Jun-ichi Yoshida 30127170	National Institute of Technology, Suzuka College, President	Deepening and Developing New Aspects of Flash Chemistry	FY2014-2018	147,700
26220805	Takeaki Ozawa 40302806	The University of Tokyo, Graduate School of Science, Professor	Methods for the Analysis and Control of Biomolecules in Living Cells Based on Molecular Imaging	FY2014-2018	150,200
26220806	Totaro Imasaka 30127980	Kyushu University, Center of Future Chemistry, Specially-appointed Professor	Laser Ionization Mass Spectrometry Using an Ultrashort Optical Pulse in the Vacuum Ultraviolet Region	FY2014-2018	150,100
26220807	Yoshitsugu Shiro 70183051	University of Hyogo, Graduate School of Life Science, Professor	Molecular Science of NO Dynamics in Biological System	FY2014-2018	150,100

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05752	Kazuo Takatsuka 70154797	Kyoto University, Fukui Institute for Fundamental Chemistry, Research Leader	Nonadiabatic Electron Dynamics in Chemistry of Charge Separation, Proton Transfer, Electron Transmission, and Huge Electronic-State Fluctuation	FY2015-2019	126,800
15H05753	Toshinori Suzuki 10192618	Kyoto University, Graduate School of Science, Professor	Ultrafast Photoelectron Spectroscopy of Solution Chemistry	FY2015-2019	146,500
15H05754	Eiichi Nakamura 00134809	The University of Tokyo, Graduate School of Science, Project Professor	Hierarchal Control of Carbon Cluster Organization and their Function	FY2015-2019	126,600
15H05755	Kazuaki Ishihara 40221759	Nagoya University, Graduate School of Engineering, Professor	Development of High Performance Acid–Base Combined Nanocatalysts	FY2015-2019	153,800
15H05756	Masahiro Murakami 20174279	Kyoto University, Graduate School of Engineering, Professor	Development of Molecular Transformations by Means of Light and Metals Directing towards Straightforward Synthesis	FY2015-2019	154,600
15H05757	Kimihisa Yamamoto 80220458	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Creation of Superatoms Based on the Precision Inorganic Synthesis and Elucidation of its Function	FY2015-2019	154,500
15H05758	Masayoshi Watanabe 60158657	Yokohama National University, Graduate School of Engineering, Professor	Role of Liquid for Controlling Autonomy of Soft Materials Containing Ionic Liquids	FY2015-2019	155,300
16H06351	Keisuke Suzuki 90162940	Tokyo Institute of Technology, School of Science, Department of Chemistry, Professor	Studies on Chemical Synthesis of Polyketide-Derived, Biologically Active Complex Natural Products	FY2016-2020	141,800
16H06352	Shigeru Yamago 30222368	Kyoto University, Institute for Chemical Research, Professor	New Organic Chemistry and Material Science of Curved π-Conjugated Molecules	FY2016-2020	145,600
16H06353	Kunio Awaga 10202772	Nagoya University, Graduate School of Science, Professor	Novel Energy and Information Conversions, Created by Solid-State Electrochemical Processes	FY2016-2020	143,000
16H06354	Masahiro Terada 50217428	Tohoku University, Graduate School of Science, Professor	Development of Functional Organosuperbase Catalysts Enabling Molecular Recognition	FY2016-2020	143,500
16H06355	Takahiro Seki 40163084	Nagoya University, Graduate School of Engineering, Professor	New polymer film processing based on the amplified conversion triggered from the free surface	FY2016-2020	138,200
16H06356	Hiroshi Sugiyama 50183843	Kyoto University, Graduate School of Science, Professor	Regulation and mechanistic investigation of gene expression by artificial genetic switches	FY2016-2020	133,700
17H06141	Shin-ichi Adachi 60260220	High Energy Accelerator Research Organization, Institute of Materials Structure Science, Professor	Visualizing ultrafast dynamics of molecular structure with femtosecond X-ray solution scattering	FY2017-2021	154,400
17H06142	Hisashi Yamamoto 20026298	Chubu University, Molecular Catalyst Research Center, Professor	New Frontier of Substrate-Controlled Chemical Reaction	FY2017-2021	159,200
17H06143	Nobuharu Iwasawa 40168563	Tokyo Institute of Technology, School of Science, Professor	Development of Carbon Dioxide Fixation Reactions	FY2017-2021	161,300
17H06144	Jian Ping Gong 20250417	Hokkaido University, Faculty of Advanced Life Science, Professor	Utilizing the Sacrificial Bonding Principle to Create Soft-Hard Composites with Toughness that Surpasses Metals and Novel Functions	FY2017-2021	157,000
17H06145	Ryoji Kanno 90135426	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Creation of superionic conductors	FY2017-2020	129,500

○ Engineering（ 54 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26220901	Kohji Minoshima 50174107	Osaka University, Graduate School of Engineering, Professor	Essence of Size Effects on Strength of Metallic Nano-Films	FY2014-2018	149,900
26220902	Mitsuteru Inoue 90159997	Toyohashi University of Technology, Graduate School of Engineering, Professor	Artificial Magnetic Lattices with Introducing Nanoscale Structures and its Engineering Applications	FY2014-2018	147,000
26220903	Hiroshi Kawarada 90161380	Waseda University, Faculty of Science and Engineering, Professor	Electron Spin Control of Diamond by Surface Carrier and its Application to Nuclear Spin Detection of Biomolecules	FY2014-2018	146,300
26220904	Nobuyuki Yoshikawa 70202398	Yokohama National University, Graduate School of Engineering, Professor	Study on Adiabatic Single-Flux-Quantum Circuits Operating in the Thermodynamic Energy Limit	FY2014-2018	150,300
26220905	Ken-ichi Sato 00377805	Nagoya University, Graduate School of Engineering, Professor	Data-Centric New Generation Photonic Networking	FY2014-2018	154,500
26220906	Masao Kuwahara 50183322	Tohoku University, Graduate School of Information Sciences, Professor	Dynamic Risk Management of Transport Network Using Mobile Data	FY2014-2018	150,000
26220907	Hideki Hosoda 10251620	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Quest for Fundamental Dynamics of Domain Homo Interface in Shape Change Materials and Principles for High Performance Materials	FY2014-2018	140,000
26220908	Masaya Nogi 80379031	Osaka University, The Institute of Scientific and Industrial Research, Professor	Nonvolatile Resistive Memory Using Cellulose Nanopaper	FY2014-2018	135,400
26220909	Zenji Horita 20173643	Kyushu University, Faculty of Engineering, Professor	Microstructual Control Using High Pressure Allotropy	FY2014-2018	140,000
26220910	Toru H. Okabe 00280884	The University of Tokyo, Institute of Industrial Science, Professor	Development of Environmentally Sound Recycling Technology for Precious Metals and Rare Metals	FY2014-2018	147,900
26220911	Hiromi Yamashita 40200688	Osaka University, Graduate School of Engineering, Professor	Design and Applications of Single-site Photocatalysts Using Nano-space	FY2014-2018	110,500
26220912	Nobuo Takeda 10171646	The University of Tokyo, Graduate School of Frontier Sciences, Visiting Collaborative Researcher (Professor Emeritus)	Intelligent Manufacturing Science of Innovative Composite Structures Based on Optical-Fiber Life Cycle Monitoring	FY2014-2018	117,800
26220913	Hidetoshi Hashizume 80198663	Tohoku University, Graduate School of Engineering, Professor	Demonstration of a Remountable High-temperature Superconducting Magnet and Construction of Universal Joints toward the Realization of an Innovative Fusion Reactor	FY2014-2018	144,400
15H05759	Wei Gao 70270816	Tohoku University, Graduate School of Engineering, Professor	Frontier of Precision Optical Metrology Created by the Ultra-Precision Optical Nano-Grid Reference Artifact and the Absolute Optical Scale Comb	FY2015-2019	77,700
15H05760	Shigeo Maruyama 90209700	The University of Tokyo, Graduate School of Engineering, Professor	Construction of Functionalized Carbon Nano-Materials and Development of Innovative Energy Devices	FY2015-2019	154,100
15H05761	Makoto Kaneko 70224607	Osaka University, Graduate School of Engineering, Professor	Cell Exercise toward Elastic Cellular Tissue	FY2015-2018	114,100
15H05762	Seiichi Miyazaki 70190759	Nagoya University, Graduate School of Engineering, Professor	Formation of Self-Aligned Super-Atom-Like Si-Ge Based Quantum Dots and Characterization of their Optical and Electrical Properties	FY2015-2018	152,300

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05763	Shigehisa Arai 30151137	Tokyo Institute of Technology, Institute of Innovative Research, Professor	Creation of Ultra-low Power-consumption Semiconductor Membrane Photonic Integrated Circuits toward On-chip Optical Interconnections	FY2015-2018	153,200
15H05764	Keiji Enpuku 20150493	Kyushu University, Research Institute of Superconductor Science and Systems, Professor	Development of Advanced Biosensing Systems Utilizing Magnetic Markers and Magnetic Sensors	FY2015-2019	131,200
15H05765	Eiichi Nakakita 70183506	Kyoto University, Disaster Prevention Research Institute, Professor	Integrated Research on State-of-the-art Multi-sensors In-situ Observation of Storm Genesis and Reduction of Serious Disaster due to Heavy Rainfall	FY2015-2019	159,500
15H05766	Ryosuke Kainuma 20202004	Tohoku University, Graduate School of Engineering, Professor	Ferrous Structural Superelastic Alloys - New Stage of Shape Memory Materials -	FY2015-2019	154,100
15H05767	Nobuhiro Tsuji 30263213	Kyoto University, Graduate School of Engineering, Professor	Novel Material Design Based on Unified Understanding on Unique Mechanical Behaviors in Bulk Nanostructured Metals	FY2015-2019	154,700
15H05768	Setsuo Takaki 90150490	Kyushu University, Research Center for Steel, Specially-appointed Professor	Systematization of Academic Foundation on Grain Refinement Strengthening in Steel	FY2015-2019	121,600
15H05769	Eiichi Tamiya 60179893	Osaka University, Graduate School of Engineering, Professor	Development of Digital Bio-Molecular Device and Biomedical Applications	FY2015-2019	129,700
15H05770	Kimiya Komurasaki 90242825	The University of Tokyo, Graduate School of Engineering, Professor	Discharge Induced in a High-Energy Electromagnetic Beam and its Engineering Applications	FY2015-2019	154,500
15H05771	Yasuhiro Kato 40221882	The University of Tokyo, Graduate School of Engineering, Professor	New Developments in Science and Engineering of Mineral Resources from Present and Past Oceans	FY2015-2019	154,500
16H06357	Hideo Miura 90361112	Tohoku University, Graduate School of Engineering, Professor	Establishment of Scientific Basis of the Strength and Reliability of Materials Based on the Order of Atom Arrangement and Its Application to the Explication of the Degradation Process of Various Materials	FY2016-2020	80,800
16H06358	Kazuto Yamauchi 10174575	Osaka University, Graduate School of Engineering, Professor	Development of zoom condenser system for X-ray free electron laser by high precision deformable reflective optics	FY2016-2020	141,800
16H06359	Akihiro Murayama 00333906	Hokkaido University, Graduate School of Information Science and Technology, Professor	Photoelectric conversion system of spin-information utilizing semiconductor quantum dots	FY2016-2020	142,500
16H06360	Yasuo Cho 40179966	Tohoku University, Research Institute of Electrical Communication, Professor	Origin elucidation of problems in interface electric charge transportation phenomenon by using scanning nonlinear dielectric microscopies	FY2016-2020	149,700
16H06361	Taiichi Otsuji 40315172	Tohoku University, Research Institute of Electrical Communication, Professor	Creation of 2D-Atomically-Thin-Layered Hetero- junctions and their Applications to Novel Terahertz Photonic Devices	FY2016-2020	144,600
16H06362	Yoshihiko Matsui 00173790	Hokkaido University, Faculty of Engineering, Professor	Innovative Water Treatment System Combining Pretreatments and Membrane Separation for Sustainable Supply of Safe High-quality Water	FY2016-2020	100,800
16H06363	Takayoshi Aoki 10202467	Nagoya City University, Graduate School of Design and Architecture, Professor	Development of Preservation/Renovation Techniques for Seismic Performance Improvement and Authenticity of Historical Buildings	FY2016-2020	136,300
16H06364	Tadaaki Nagao 40267456	National Institute for Materials Science, International Center for Materials Nanoarchitectonics, Group Leader / MANA Principal Investigator	Infrared Energy Harvester by Artificially Structured Heterojunction	FY2016-2020	141,400

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
16H06365	Kaneaki Tsuzaki 40179990	Kyushu University, Graduate School of Engineering, Professor	Research on supreme fatigue property in steel: importance of microstructurally-small fatigue crack	FY2016-2020	151,000
16H06366	Sadahiro Tsurekawa 40227484	Kumamoto University, Faculty of Advanced Science and Technology, Professor	Breakthrough toward “second-generation” grain boundary engineering	FY2016-2020	137,900
16H06367	Tadasumi Adschiri 60182995	Tohoku University, WPI - Advanced Institute for Materials Research (WPI-AIMR), Professor	Fabrication of fluidic ceramics with supercritical fluid technology toward dynamic thermal management	FY2016-2020	140,700
16H06368	Suguru Noda 50312997	Waseda University, School of Advanced Science and Engineering, Professor	Creating Soft-Batteries by Simple and Rapid Processes and Innovating Capacity by Reversible Structure Change	FY2016-2020	142,900
16H06369	Masahiro Goto 10211921	Kyushu University, Graduate School of Engineering, Professor	Creation of Transdermal Drug Delivery Systems Using Solid-in-oil Nano-dispersion Technique	FY2016-2020	128,500
16H06370	Hiroyuki Koizumi 40361505	The University of Tokyo, Graduate School of Frontier Sciences, Associate Professor	All-round Micro-propulsion System for Multipurpose Utilization of Microsatellite	FY2016-2020	128,800
17H06146	Yang Ju 60312609	Nagoya University, Graduate School of Engineering, Professor	Creation and development of high-order nano-space structures through innovative control of stress field	FY2017-2021	161,000
17H06147	Atsuo Kawamura 80186139	Yokohama National University, Faculty of Engineering, Professor	Realization of Sustainable Green Society Through 99.9% Class Efficiency Electric Power Conversion	FY2017-2021	138,000
17H06148	Shinichi Takagi 30372402	The University of Tokyo, School of Engineering, Professor	Precise structure control of 3-dimensional integration CMOS using high mobility materials through layer transfer	FY2017-2021	158,900
17H06149	Takao Someya 90292755	The University of Tokyo, School of Engineering, Professor	Evaluation of Drug Response by Elastic Multipoint Electrode Array Using Cardiomyocyte Sheet	FY2017-2021	157,100
17H06150	Koichi Osuka 50191937	Osaka University, Graduate School of Engineering, Professor	Source of various behaviors of living things that understands from zombification of insects	FY2017-2021	136,800
17H06151	Toshiharu Ikaga 30302631	Keio University, Faculty of Science and Technology, Professor	Field survey on Impact of living environments on brain, cardiovascular, respiratory and locomotive system, and co-benefit evaluation of disease and long-term care prevention	FY2017-2021	159,700
17H06152	Kazuhiro Hono 60229151	National Institute for Materials Science, Vice President and Director of Research Center for Magnetic and Spintronic Materials	Spin-dependent conduction mechanism of half-metallic Heusler alloys and applications to practical devices	FY2017-2021	162,400
17H06153	Hideo Hosono 30157028	Tokyo Institute of Technology, Institute of Innovative Research, Professor	New evolution of materials concept and application of electrides	FY2017-2021	134,600
17H06154	Akihiro Makino 30315642	Tohoku University, New Industry Creation Hatchery Center, Professor	Research and development on artificial production of next generation of Rare-Earth Free Magnets with $L1_0$ phase similar to Cosmic magnet.	FY2017-2021	156,600
17H06155	Hideyuki Yasuda 60239762	Kyoto University, Graduate School of Science and Engineering, Professor	Modeling of solidification dynamics supported by 3D time-resolved in-situ observations	FY2017-2021	130,200
17H06156	Yuji Wada 40182985	Tokyo Institute of Technology, School of Materials and Chemical Technology, Professor	The Theory of Microwave-induced Nonequilibrium State and its Application to the Manipulation of Solid/Interfacial Chemical Reactions	FY2017-2021	160,200

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06157	Takeshi Omasa 00252586	Osaka University, Graduate School of Engineering, Professor	Integrated platform for mammalian cell-based cell and bioprocess engineering	FY2017-2021	118,400
17H06158	Haruko Takeyama 60262234	Waseda University, Faculty of Science and Engineering, Professor	Development of platform for ultra high-throughput screening of novel bioactive compound producers	FY2017-2021	157,700
17H06159	Hiroyuki Takahashi 70216753	The University of Tokyo, Institute of Engineering Innovation, Professor	Study on Multi-photon gamma-ray coincidence tomography	FY2017-2021	158,300

(4) Biological Sciences (81 Projects)

○ Biological Sciences (15 Projects)

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26221001	Haruo Kasai 60224375	The University of Tokyo, Graduate School of Medicine, Professor	Study of Cerebral Synapses and Circuits Using Two-photon Microscopy and Novel Optoprobes	FY2014-2018	150,000
26221002	Kei Ito 00311192	The University of Tokyo, Institute for Quantitative Biosciences, Associate Professor	Connectomics Analysis of the Neural Networks that Regulate the Behavior of Drosophila	FY2014-2018	128,400
26221003	Tadashi Isa 20212805	Kyoto University, Graduate School of Medicine, Professor	Elucidating the Neural Mechanism to Generate the "Partial Awareness" by Large-scaled Neuron Network Analysis and Circuit Manipulation Techniques in Non-human Primates	FY2014-2018	150,000
26221004	Satoru Takahashi 50271896	University of Tsukuba, Faculty of Medicine, Professor	Development of New *in vivo* Imaging Technologies by Using "Biological Optical Window"	FY2014-2018	88,500
26221005	Yutaka Kawakami 50161287	Keio University, School of Medicine, Professor	Investigation of Differential Immune Status among Cancer Patients and Development of Personalized Cancer Therapy by Combining Immunomodulation	FY2014-2018	150,100
15H05772	Michisuke Yuzaki 40365226	Keio University, School of Medicine, Professor	How are Synapses Formed, Fine-tuned and Eliminated in vivo?—Novel Mechanisms by the Complement Family Proteins	FY2015-2019	135,800
15H05773	Yukiko Gotoh 70252525	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	Elucidation of Mechanisms Regulating Neural Stem/Progenitor Cell Fate	FY2015-2019	143,000
15H05774	Kohei Miyazono 90209908	The University of Tokyo, Graduate School of Medicine, Professor	Transcriptional Regulation by TGF-β Signaling and its Relation to Progression of Cancer	FY2015-2019	153,800
16H06371	Daisuke Yamamoto 50318812	National Institute of Information and Communications Technology, Advanced ICT Research Institute, Executive Researcher	How sexual experience modulates innate behavior: a neurogenetic study in Drosophila	FY2016-2020	140,900
16H06372	Nobutaka Hirokawa 20010085	The University of Tokyo, Graduate School of Medicine, Project Professor	Integrated studies of regulation of neuronal function and development by kinesin superfamily motors, KIFs	FY2016-2018	142,900
16H06373	Masanori Hatakeyama 40189551	The University of Tokyo, Graduate School of Medicine, Professor	Mechanism and regulation of "Hit-and-Run" carcinogenesis by Helicobacter pylori CagA	FY2016-2020	141,600
16H06374	Akira Kikuchi 10204827	Osaka University, Graduate School of Medicine, Professor	Investigation of the novel mechanisms underlying tumorigenesis due to aberrant Wnt signal networks	FY2016-2020	136,300

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06160	Hitoshi Sakano 90262154	University of Fukui, Faculty of Medical Sciences, Adjunct Professor	Decision Making in the Mouse Olfactory System	FY2017-2021	158,800
17H06161	Yasushi Miyashita 40114673	RIKEN, Center for Brain Science, Laboratory for Cognition Circuit Dynamics, Team Leader	Elucidation of cortical neural circuits for meta-memory: Optogenetic manipulation of retrospection	FY2017-2021	161,000
17H06162	Hiroyoshi Nishikawa 10444431	Nagoya University, Graduate School of Medicine, Professor	Association of immune responses with racial differences of cancer development	FY2017-2021	161,700

○ Biology（ 18 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26221101	Eisuke Nishida 60143369	RIKEN, Center for Biosystems Dynamics Research, Center Director	Signal Transduction Networks Regulating Life-span and Development	FY2014-2018	150,000
26221103	Koh Iba 10192501	Kyushu University, Faculty of Science, Professor	Higher-Order Functions of Stomatal Guard Cells in Plant Environmental Adaptation	FY2014-2018	150,100
26221104	Yoshitaka Oka 70143360	The University of Tokyo, Graduate School of Science, Professor	Coordinated Regulation of Reproduction and Sexual Behavior by Peptidergic Neurons	FY2014-2018	77,700
26221105	Tetsuji Kakutani 20332174	Research Organization of Information and Systems, National Institute of Genetics, Professor	Controlling Mechanism of Epigenome by Silencing and Anti-silencing	FY2014-2018	147,600
26221106	Hiroshi Kudoh 10291569	Kyoto University, Center for Ecological Research, Professor	Biological Synchronization in Natural Environments	FY2014-2018	150,100
15H05775	Yoshinori Fujiyoshi 80142298	Nagoya University, Cellular and Structural Physiology Institute, Professor	Studies in Structural Physiology of Channels	FY2015-2019	138,500
15H05776	Ikuko Hara-Nishimura 00241232	Konan University, Faculty of Science and Engineering, Professor	Endomembrane-Mediated Organ Straightening and Defense in Plants	FY2015-2019	153,800
15H05777	Akihisa Terakita 30212062	Osaka City University, Graduate School of Science, Professor	Contribution of Opsin Properties to Non-Visual Functions	FY2015-2019	134,400
15H05778	Haruhiko Fujiwara 40183933	The University of Tokyo, Graduate School of Frontier Sciences, Professor	Molecular Mechanisms of Color Pattern Formation in Mimicry Controlled by Supergene.	FY2015-2019	153,800
16H06375	Yoshinori Ohsumi 30114416	Tokyo Institute of Technology, Frontier Research Center, Professor	Molecular mechanism and physiological understanding of Autophagy	FY2016-2020	143,700
16H06376	Kiyokazu Agata 70167831	Gakushuin University, Faculty of Science, Department of Life Science, Professor	Evoking limb regeneration from non-regenerative animals	FY2016-2020	136,800
16H06377	Hiroo Fukuda 10165293	The University of Tokyo, Graduate School of Science, Professor	Molecular basis of pluripotency of vascular stem cells	FY2016-2020	141,800
16H06378	Mitsuyasu Hasebe 40237996	National Institute of Natural Sciences, National Institute for Basic Biology, Division of Evolutionary Biology, Professor	Spatiotemporal regulation of cell division axis as a grand plan of plant developmental evolution	FY2016-2020	150,100

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06164	Hiroyuki Arai 40167987	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	The roles of membrane lipids for intracellular signaling platform	FY2017-2021	156,700
17H06165	Shuji Akiyama 50391842	National Institute of Natural Sciences, Institute for Molecular Science, Research Center of Integrative Molecular Systems, Professor	An Integrated Multi-scale Approach for Studying Cyanobacterial Circadian Clock System	FY2017-2021	157,400
17H06166	Yumiko Saga 50221271	Research Organization of Information and Systems, National Institute of Genetics, Genetic Strains Research Center, Professor	Mechanism of sex differentiation of germ cells	FY2017-2021	156,200
17H06167	Tatsuo Fukagawa 60321600	Osaka University, Graduate School of Frontier Biosciences, Professor	Molecular mechanisms for centromere formation	FY2017-2021	157,100
17H07424	Takayuki Kohchi 40202056	Kyoto University, Graduate School of Biostudies, Professor	Sex differentiation in land plant: mechanism of genetic robustness and plasticity	FY2017-2021	141,500

○ Agricultural Sciences（ 15 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26221202	Kazuhiro Irie 00168535	Kyoto University, Graduate School of Agriculture, Professor	Novel Preventive Strategy for Alzheimer's Disease Based on the "Toxic Conformation Theory" of Amyloid	FY2014-2018	126,500
26221204	Minoru Yoshida 80191617	RIKEN, Center for Sustainable Resource Science, Group Director	Development of Novel Methods for Target Identification of Natural Products and their Application to Chemical Epigenetics	FY2014-2018	150,200
15H05779	Ryohei Terauchi 50236981	Kyoto University, Graduate School of Agriculture, Professor	Towards Understanding Molecular Interactions of Rice and the Blast Fungus Magnaporthe Oryzae	FY2015-2019	151,500
15H05780	Yasuyuki Kubo 80183797	Kyoto Prefectural University, Graduate School of Life and Environmental Sciences, Professor	Molecular Basis of Infection Strategy in Plant Pathogenic Fungi: Host Recognition and Infection Structure Development	FY2015-2019	98,500
15H05781	Ryuichiro Sato 50187259	The University of Tokyo, Graduate School of Agriculture and Life Sciences, Professor	Analysis on Molecular Nutritional Functions of Bile Acids as a Feeding Signal, and Regulation of Metabolic Response to Feeding by Food Factors	FY2015-2019	147,700
16H06379	Amane Makino 70181617	Tohoku University, Graduate School of Agricultural Sciences, Professor	Production of Super High-yielding Rice Plants for Environmental Conservation as the Green Evolution II	FY2016-2020	108,300
16H06380	Seiji Takayama 70273836	The University of Tokyo, Graduate School of Agriculture and Life Sciences, Professor	Molecular Mechanism and Evolution of Self-Incompatibility in Plants	FY2016-2020	140,800
16H06381	Yoshihiko Sako 60153970	Kyoto University, Graduate School of Agriculture, Professor	Comprehensive, Spatiotemporal Study and Applied Research of Carboxydotrophs	FY2016-2020	133,100
16H06382	Yasuhisa Adachi 70192466	University of Tsukuba, Faculty of Life and Environmental Science, Professor	Environmental Interface Engineering Based on Dynamic Analysis of Colloidal Focculation	FY2016-2020	102,000
16H06383	Hiroshi Matsuda 80145820	Tokyo University of Agriculture and Technology, Institute of Agriculture, Professor	Redefinition of intractable inflammatory diseases based on mast cell activation syndrome	FY2016-2020	144,900
17H06168	Makoto Nishiyama 00208240	The University of Tokyo, Biotechnology Research Center, Professor	Studies on mechanisms of biosynthesis of biomolecules via amino-group carrier protein and expansion of structural diversity of secondary metabolites	FY2017-2021	160,700

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06169	Yasuhisa Asano 00222589	Toyama Prefectural University, Faculty of Engineering, Professor	Development of soluble expression technology and utilization of enzymes from plants and animals	FY2017-2021	157,700
17H06170	Koji Uchida 40203533	The University of Tokyo, Graduate School of Agriculture and Life Sciences, Professor	Life science basis of short-lived reactive species originated from foods	FY2017-2021	157,100
17H06171	Shinya Funakawa 20244577	Kyoto University, Graduate School of Global Environmental Studies, Professor	Establishment of “Minimum-loss” agriculture	FY2017-2021	148,500
17H06172	Ken Shirasu 20425630	RIKEN, Center for Sustainable Resource Science, Group Director	Molecular elucidation of plant-pathogen interactions	FY2017-2021	156,100

○ Medicine, Dentistry, and Pharmacy（ 33 Projects ）

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
26221301	Takeo Kawabata 50214680	Kyoto University, Institute for Chemical Research, Professor	Regioselective Molecular Transformation of Multifunctionalized Molecules	FY2014-2018	93,600
26221303	Emi Nishimura 70396331	Tokyo Medical and Dental University, Medical Research Institute, Professor	Stem Cell Regulation and Dynamics in Hair Follicle Regeneration and Aging	FY2014-2018	150,000
26221304	Masahide Takahashi 40183446	Nagoya University, Graduate School of Medicine, Professor	Functional Analyses of Girdin Family Proteins and their Roles in Psyco-neurologic Disease and Cancer	FY2014-2018	149,800
26221305	Toshinori Nakayama 50237468	Chiba University, Graduate School of Medicine, Professor	Generation and Maintenance of Pathogenic Immunological Memory and its Regulation	FY2014-2018	150,000
26221306	Tomohiro Kurosaki 50178125	Osaka University, WPI Immunology Frontier Research Center, Professor	Intrinsic and Extrinsic Mechanisms of Generation and Maintenance of Memory B Cells	FY2014-2018	150,000
26221307	Mamoru Watanabe 10175127	Tokyo Medical and Dental University, Graduate School of Medical and Dental Sciences, Professor	Designing and Developing Innovative Use of Newly Discovered Colonic Epithelial Culture Method Applicable to Clinical Medicine	FY2014-2018	150,100
26221308	Seishi Ogawa 60292900	Kyoto University, Graduate School of Medicine, Professor	Exploring Genetic Basis of Myelodysplastic Syndromes (MDS)	FY2014-2018	149,900
15H05783	Kazuhisa Sekimizu 90126095	Teikyo University, Institute of Medical Mycology, Professor	Development of Novel Anti-Infectious Drugs Exhibiting Therapeutic Effects	FY2015-2019	154,500
15H05784	Tasuku Honjo 80090504	Kyoto University, Institute for Advanced Study, Deputy Director-General and Distinguished Professor	Regulatory Mechanism of Immunoglobulin Gene Diversification and Genome Instability by RNA-Editing Catalyzed by Activation-Induced Cytidine Deaminase (AID)	FY2015-2018	153,500
15H05785	Shigekazu Nagata 70114428	Osaka University, Immunology Frontier Research Center, Professor	Engulfment of Apoptotic Cells and Asymmetry of Plasma Membranes	FY2015-2019	118,100
15H05786	Hajime Karasuyama 60195013	Tokyo Medical and Dental University, Graduate School of Medical and Dental Sciences, Professor	Previously Unappreciated Roles for Basophils in Health and Disease	FY2015-2018	154,000
15H05787	Tadatsugu Taniguchi 50133616	The University of Tokyo, Institute of Industrial Science, Project Professor	Elucidation of the Host’s Homeostatic Responses by the Regulation of Immune System and its Application to the Prevention and Treatment of Immunological Disorders	FY2015-2019	132,300

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
15H05788	Toshiro Fujita 10114125	The University of Tokyo, Research Center for Advanced Science and Technology, Emeritus Professor	Development of a Novel Strategy for Life Style Disease through Exploration of the Roles of Mineral- and Gluco-Corticoids in Hypertension and Organ Dysfunction	FY2015-2019	153,800
15H05789	Kohjiro Ueki 00396714	The University of Tokyo, Graduate School of Medicine, Professor	Development of a Novel Anti-Aging Strategy by Elucidating the Mechanisms Regulating Aging through a Muscle Centric Organ Network	FY2015-2019	153,800
15H05790	Kenji Kabashima 00362484	Kyoto University, Graduate School of Medicine, Professor	Understanding the Mechanism How the Skin Responses to External Stimuli	FY2015-2019	147,000
15H05791	Masaki Mori 70190999	Osaka University, Graduate School of Medicine, Professor	Achievement of Highly Accurate Diagnosis of Early Pancreatic Cancer in Japanese Patients through a Comprehensive/ Integrated Approach	FY2015-2019	153,800
15H05792	Yoshihiko Maehara 80165662	Fukuoka Dental College, Faculty of Oral Dentistry, Guest professor	Development of Innovative Treatment Targeting the Sphere Formation Mechanism Involving Cancer Stem Cells	FY2015-2019	144,000
16H06384	Yoshiji Takemoto 20227060	Kyoto University, Graduate School of Pharmaceutical Sciences, Professor	Innovative catalysts for the synthesis of large- and medium-sized molecules bearing glycopeptides	FY2016-2020	123,300
16H06385	Masayuki Miura 50202338	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	Mechanisms and physiological functions of intercellular communication by cell death	FY2016-2020	140,900
16H06386	Akihiro Kusumi 50169992	Okinawa Institute of Science and Technology Graduate University, Membrane Cooperativity Unit, Professor	Signal transduction by transient molecular complexes and its regulation by actin membrane skeleton: single-molecule tracking study	FY2016-2020	145,500
16H06387	Akira Shibuya 80216027	University of Tsukuba, Life Science Center for Survival Dynamics, Tsukuba Advanced Research Alliance, Professor	Regulation of innate immune responses by inhibitory immunoreceptors	FY2016-2020	142,600
16H06388	Kensuke Miyake 60229812	The University of Tokyo, Institute of Medical Science, Professor	The study on the molecular and cellular bases underlying the crosstalks between innate immunity and cell metabolism in lysosomes	FY2016-2020	140,900
16H06389	Toru Miyazaki 30396270	The University of Tokyo, Faculty of Medicine, Professor	Elucidation of the mechanism required for AIM activation, and its therapeutic application to NASH-induced hepatocellular carcinoma	FY2016-2020	133,800
16H06390	Juro Sakai 80323020	Tohoku University, Graduate School of Medicine, Professor	Elucidation of lifestyle-related diseases development due to environmental factors and epigenetic memory	FY2016-2020	140,700
16H06391	Koichi Akashi 80380385	Kyushu University, Graduate School of Medicine, Professor	Regulation of self-renewal vs. quiescence status in human myeloid leukemia stem cells	FY2016-2020	118,500
16H06393	Riko Nishimura 60294112	Osaka University, Graduate School of Dentistry, Professor	Development of innovative medical technology based on integrated understanding of both protection and destruction of articular cartilage homeostasis	FY2016-2020	139,900
17H06173	Masanobu Uchiyama 00271916	The University of Tokyo, Graduate School of Pharmaceutical Sciences, Professor	New Molecular Technologies to Open Up Multiple Applications of Light in Life Science and Materials Science	FY2017-2021	163,300
17H06174	Kazuhiro Iwai 60252459	Kyoto University, Graduate School of Medicine, Professor	Extensive analyses of the LUBAC ubiquitin ligase	FY2017-2021	157,100
17H06175	Akihiko Yoshimura 90182815	Keio University, School of Medicine, Professor	Immune systems involved in the resolution of inflammation and tissue repair	FY2017-2021	158,300
17H06176	Toshiro Sato 70365245	Keio University, School of Medicine, Associate Professor	Gaining Integrative Understanding of Gastrointestinal Disease Phenotypes through Establishment of an Organoid Library	FY2017-2021	159,000

Research Project Number	Principal Investigator (Name, Researcher Number, Research Institution)		Title	Term of Project	Total (Thousands of Yen)
17H06177	Ryuichi Nishinakamura 70291309	Kumamoto University, Institute of Molecular Embryology and Genetics, Professor	Kidney reconstitution and disease modeling based on nephron induction methods in vitro	FY2017-2021	157,100
17H06178	Toshihide Yamashita 10301269	Osaka University, Graduate School of Medicine, Professor	Generation of neural network repair medicine	FY2017-2021	158,600
17H06179	Yumiko Imai 50231163	National Institute of Biomedical Innovation, Health and Nutrition, Laboratory for Regulation of Intractable Infectious Diseases, Project Leader	Identification of higher-order-epigenetic modification machineries and development of potential novel therapeutics in severe virus infection	FY2017-2021	150,900

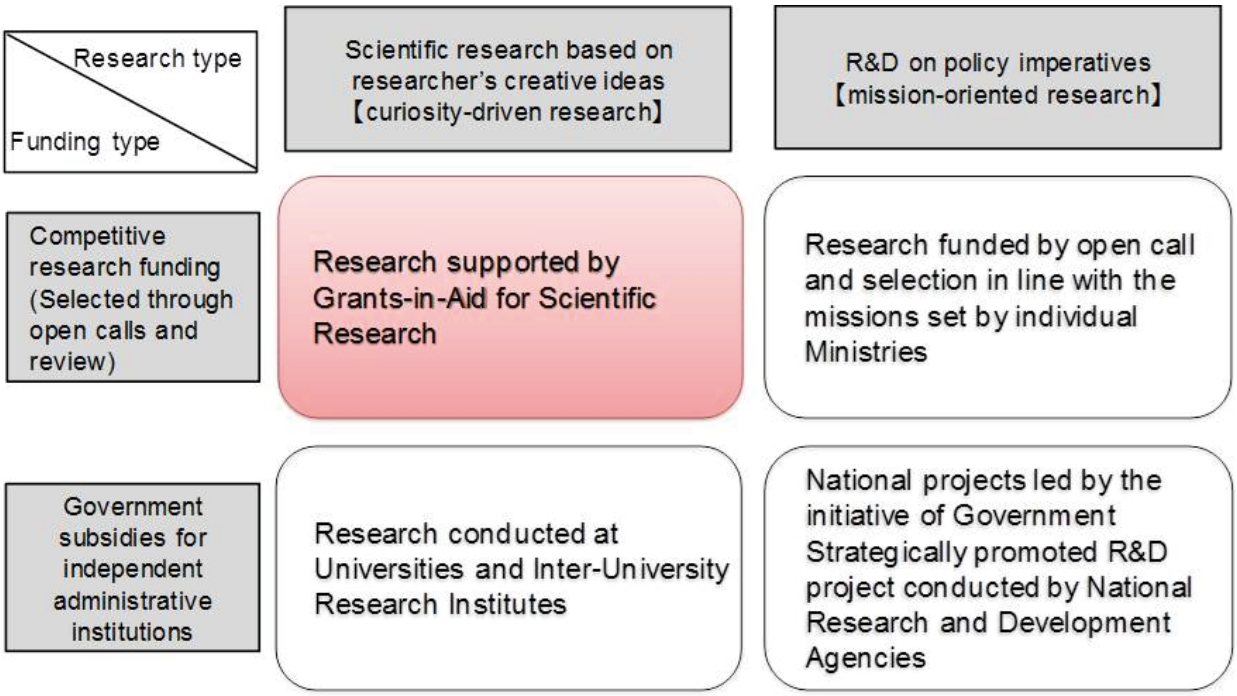
Reference

I. Outline of the Grants-in-Aid for Scientific Research-KAKENHI-

1. Purpose and Character of Grants-in-Aid for Scientific Research-KAKENHI-

Grants-in-Aid for Scientific Research are competitive funds that are intended to promote development of scientific research (based on original ideas of researchers), encompassing basic to applied researches in all fields ranging from humanities and social sciences to natural sciences. The grants provide financial support for creative and pioneering research projects that will become the foundation of social development. The research projects are selected by peer-review process.

The placement of "KAKENHI" in the policy on the promotion of science, technology and scientific research in Japan



2. Research Categories

Different research categories of KAKENHI listed below are provided so as to meet the variety of the research content and budget scale.

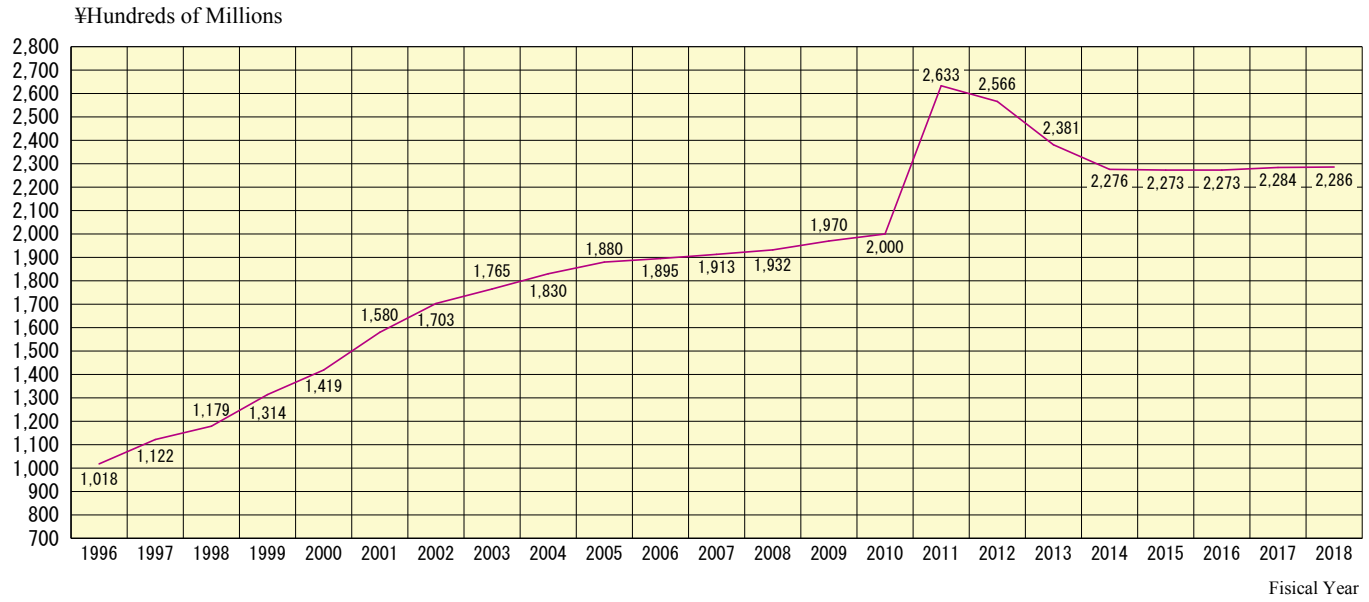
❖ As of September 2018

Research categories	Purposes and description of each research category
Grants-in-Aid for Scientific Research	
Grant-in-Aid for Specially Promoted Research	Outstanding and distinctive research conducted by one or a relatively small number of researchers expected to achieve remarkably excellent research results that open up a new scientific field. (The research period is 3 to 5 years (in a truly necessary case, period up to 7 years is acceptable.). The budget ranges from 200 million to 500 million yen per project (only in a truly necessary case, budget exceeding 500 million yen.is asked for.).
Grant-in-Aid for Scientific Research on Innovative Areas	(Research in a proposed research area) This category is intended to foster novel research areas proposed by diverse groups of researchers that are expected to lead to development and heightening of Japan's research level in the respective fields, to be conducted by collective research efforts through collaboration, scholarly training, shared use of equipment, etc. (The period is 5 years. The budget range is generally set between 10 million to 300 million yen per fiscal year per proposed area.)
Grant-in-Aid for Scientific Research	(S): Creative/pioneering research conducted by one or a relatively small number of researchers. (The period is 5 years. The budget ranges from 50 to 200 million yen per project.) (A), (B), (C): Creative/pioneering research conducted by one researcher or jointly by multiple researchers. (The period is 3 to 5 years.) (A) 3 to 5 years 20 million to 50 million yen (B) 3 to 5 years 5 million to 20 million yen (C) 3 to 5 years 5 million yen or less *Classification of (A)/(B)/(C) is according to the budget range.
Grant-in-Aid for Challenging Exploratory Research	[No new proposals have been called since FY2016.] Early-stage research conducted by one or multiple researchers which, based on a unique idea, sets a high and challenging goal. (The period is 1 to 3 years. The budget is up to 5 million yen per project.)
Grant-in-Aid for Challenging Research (Pioneering/Exploratory)	(Pioneering) (Exploratory) Research conducted by a single or multiple researchers that aims at radically transforming the existing research framework and/or changing the research direction and has a potential of rapid development. The scope of the (Exploratory) category encompasses research proposals that are highly exploratory and/or are in their budding stages. The research period and total budget range are as follows; (Pioneering) 3 to 6 years 5 million to 20 million yen (Exploratory) 2 to 3 years 5 million yen or less
Grant-in-Aid for Young Scientists	[No new proposals have been called since FY2017.] (A), (B): Research conducted individually by a researcher of age 39 or younger. The research period and total budget range are as follows; (A) 2 to 4 years 5 million to 30 million yen (B) 2 to 4 years 5 million yen or less *Classification of (A)/(B) is according to the budget range.
Grant-in-Aid for Early-Career Scientists	Research conducted by an individual researcher (*) who is less than 8 years after Ph.D. acquisition. As an interim measures, a non-Ph.D. researcher who is 39 years old or younger can also apply. (*) Individuals who are in the prospect of acquiring Ph.D. are also eligible. When counting the years after Ph.D. acquisition, the period of maternity leave and childcare leave can be excluded. (The period is 2 to 4 years. The budget is up to 5 million yen per project.)
Grant-in-Aid for Research Activity Start-up	Research conducted by a single researcher who has been freshly appointed to a research position, or who has returned from his/her maternity, childcare or other kinds of leave. (The period is up to 2 years. The budget is up to 1.5 million per fiscal year.)
Grant-in-Aid for Encouragement of Scientists	Research conducted by an individual who is ineligible for application for other KAKENHI categories (e.g. Individuals who belong to educational or research institutions, private companies, etc. and engage in the researches to contribute to the promotion of the science). (The period is 1 year. The budget range is between 100 thousand and 1 million yen per project.)
Grant-in-Aid for Special Purposes	Funding of research projects of pressing urgency and importance. (e.g. investigation of natural disaster)
Grant-in-Aid for Publication of Scientific Research Results	
Publication of Research Results	Subsidy for publication and/or international dissemination of research achievements of high academic values executed by academic associations and other organizations.

Enhancement of International Dissemination of Information	Subsidy for efforts by academic societies and other scholarly organizations to strengthen international dissemination of academic information for the purpose of international academic exchange.
Scientific Literature	Subsidy for academic publication of research results (books) authored by an individual or a group of researchers.
Databases	Subsidy for creation and operation of a database open to public use, by an individual or a group of researchers.
Grant-in-Aid for JSPS Fellows	Funding for research conducted by JSPS Fellows (including Foreign JSPS Fellows). (The period is up to 3 years.)
Fund for the Promotion of Joint International Research	
Fostering Joint International Research	(A) Support of joint international research project conducted by a KAKENHI grantee in collaboration with researcher(s) at foreign university or research institution. Over a period of 6 to 12 months. The grant seeks to markedly advance research plans for the root research project and to foster independent researchers who can be internationally competitive. (The budget is up to 12 million yen.) (*) The name is changed from FY2018 call for proposals. (B) Support of joint international research project conducted by multiple domestic researchers and researcher(s) who belongs to overseas research institution. In addition to the development of scientific research, the grant seeks to build out infrastructure of joint international research or further strengthen joint international research and to foster researchers who can be internationally competitive. (The period is 3 to 6 years. The budget is up to 20 million yen.)
International Activities Supporting Group	Support of international activities within Scientific Research on Innovative Areas. (Set period of the Area, up to 15 million yen per year) * After FY2018 call for proposal, “International Activities Supporting Group” will be incorporated into “Grant-in-Aid for Scientific Research on Innovative Areas “Administrative Group”.
Home-Returning Researcher Development Research	Support of research to be conducted by a Japanese researcher with current affiliation abroad who is to be newly appointed at university or research institution in Japan. (The period is up to 3 years. The budget is to 50 million yen.)
Generative Research Field for Scientific Research (B/C)	This category set for “Scientific Research (B/C)” is open to research proposals for which screening within the conventional framework of research fields may be difficult and/or to applicants who prefer their proposals to be screened from a broader perspective relevant to the Generative Research Field. (The research period that can be applied for differs depending on the year of application.) * After the call for proposals in FY2018, setting of a new field is suspended.

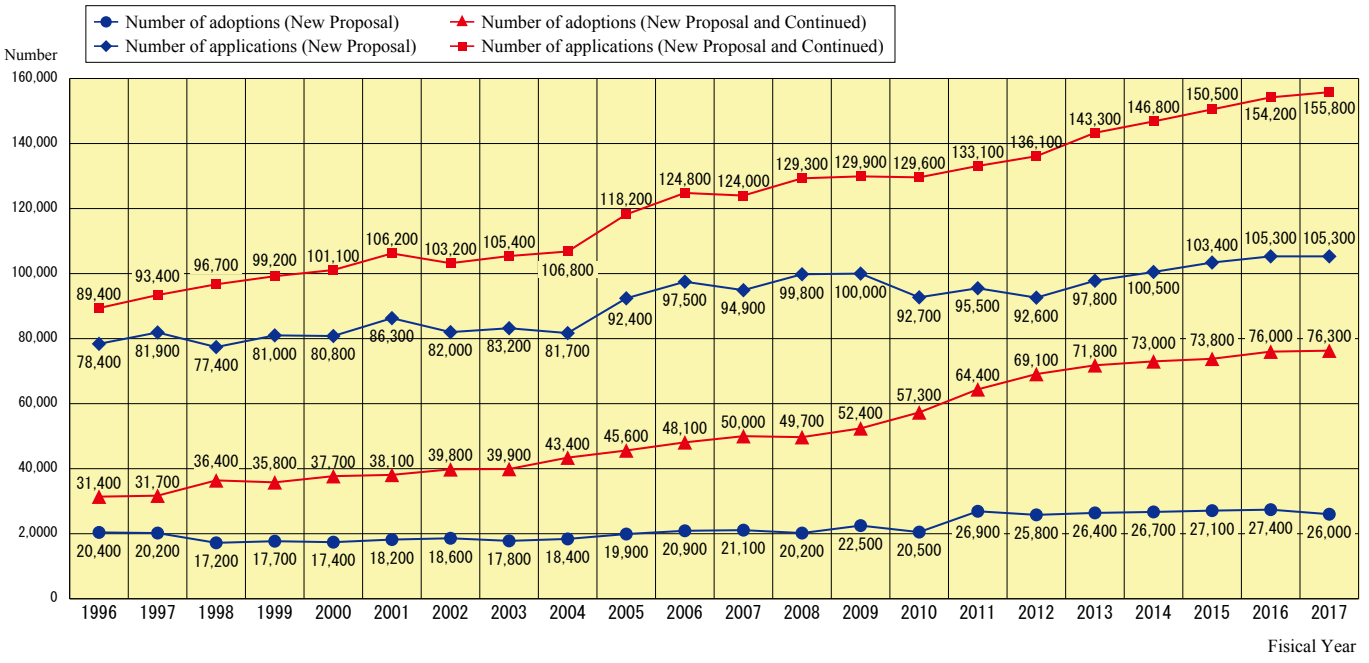
3. Changes in Budgets and Other Information

○ Changes in budgets



Fiscal Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Budget (¥hundreds of millions)	1,018	1,122	1,179	1,314	1,419	1,580	1,703	1,765	1,830	1,880	1,895	1,913	1,932	1,970	2,000	2,633	2,566	2,381	2,276	2,273	2,273	2,284	2,286
Year-on-year increase (%)	10.2	10.2	5.1	11.5	8.0	11.3	7.8	3.6	3.7	2.7	0.8	0.9	1.0	2.0	1.5	31.7	−2.5	−7.2	−4.4	−0.1	−0.1	0.5	0.1

○ State of applications and approvals



○ Approval rate (Upper column: New projects, Lower column: New and continuing projects)

Fiscal Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Adoption rate (%)	26.1	24.6	22.2	21.8	21.6	21.1	22.7	21.4	22.5	21.6	21.5	22.2	20.3	22.5	22.1	28.1	27.9	27.0	26.6	26.2	26.0	24.7
Adoption rate (%)	35.1	34.0	37.6	36.1	37.3	35.8	38.5	37.9	40.7	38.6	38.6	40.4	38.4	40.3	44.2	48.4	50.8	50.1	49.7	49.1	49.3	49.0

4. Actual Subsidization of Grants-in-Aid for Scientific Research for FY2018

(1) New Projects

As of October 2018

Research category	Number of proposed projects: Applications	Number of proposed projects: Applications approved	Approval rate	Amount allocated	Amount allocated per project: Average	Amount allocated per project: Maximum
				Thousands of Yen	Thousands of Yen	Thousands of Yen
Grants-in-Aid for Scientific Research	〔 101,247 〕 101,337	〔 25,313 〕 25,562	〔 25.0 〕 25.2	〔 64,317,621 〕 61,417,400 【 18,425,220 】	〔 2,541 〕 2,403	〔 141,500 〕 145,100
Specially Promoted Research	〔 111 〕 105	〔 13 〕 12	〔 11.7 〕 11.4	〔 1,387,900 〕 1,123,500 【 337,050 】	〔 106,762 〕 93,625	〔 141,500 〕 145,100
Scientific Research on Innovative Areas (Research in a proposed research area)	〔 5,908 〕 6,158	〔 996 〕 1,011	〔 16.9 〕 16.4	〔 6,482,521 〕 6,383,500 【 1,915,050 】	〔 6,509 〕 6,314	〔 129,100 〕 139,400
Scientific Research	〔 54,739 〕 58,322	〔 15,429 〕 15,825	〔 28.2 〕 27.1	〔 39,865,900 〕 40,764,600 【 12,229,380 】	〔 2,584 〕 2,576	〔 89,600 〕 105,100
Scientific Research (S)	〔 645 〕 704	〔 81 〕 80	〔 12.6 〕 11.4	〔 3,343,200 〕 3,279,800 【 983,940 】	〔 41,274 〕 40,998	〔 89,600 〕 105,100
Scientific Research (A)	〔 2,567 〕 2,454	〔 636 〕 605	〔 24.8 〕 24.7	〔 7,157,300 〕 7,310,100 【 2,193,030 】	〔 11,254 〕 12,083	〔 32,000 〕 32,900
Scientific Research (B)	〔 11,041 〕 11,577	〔 2,729 〕 2,965	〔 24.7 〕 25.6	〔 13,757,100 〕 15,170,200 【 4,551,060 】	〔 5,041 〕 5,116	〔 13,500 〕 12,800
Scientific Research (C) (*1)	〔 40,486 〕 43,587	〔 11,983 〕 12,175	〔 29.6 〕 27.9	〔 15,608,300 〕 15,004,500 【 4,501,350 】	〔 1,303 〕 1,232	〔 3,400 〕 3,200
Challenging Research	〔 15,607 〕 12,634	〔 1,680 〕 1,508	〔 10.8 〕 11.9	〔 4,413,700 〕 3,832,100 【 1,149,630 】	〔 2,627 〕 2,541	〔 16,200 〕 17,500
Challenging Research (Pioneering)	〔 1,116 〕 823	〔 94 〕 82	〔 8.4 〕 10.0	〔 643,900 〕 595,500 【 178,650 】	〔 6,850 〕 7,262	〔 16,200 〕 17,500
Challenging Research (Exploratory) (*1)	〔 14,491 〕 11,811	〔 1,586 〕 1,426	〔 10.9 〕 12.1	〔 3,769,800 〕 3,236,600 【 970,980 】	〔 2,377 〕 2,270	〔 4,700 〕 4,500
Young Scientists (*1,3)	〔 — 〕 20,369	〔 — 〕 6,256	〔 — 〕 30.7	〔 — 〕 8,273,100 【 2,481,930 】	〔 — 〕 1,322	〔 — 〕 3,100
Young Scientists (A)(*2)	〔 1,837 〕 —	〔 433 〕 —	〔 23.6 〕 —	〔 3,277,700 〕 — 【 — 】	〔 7,570 〕 —	〔 18,100 〕 —
Young Scientists (B)(*2)	〔 19,271 〕 —	〔 5,817 〕 —	〔 30.2 〕 —	〔 7,913,600 〕 — 【 — 】	〔 1,360 〕 —	〔 3,200 〕 —
Research Activity Start-up	〔 3,774 〕 3,749	〔 945 〕 950	〔 25.0 〕 25.3	〔 976,300 〕 1,040,600 【 312,180 】	〔 1,033 〕 1,095	〔 1,500 〕 1,200
Fund for the Promotion of Joint International Research	〔 — 〕 2,335	〔 — 〕 234	〔 — 〕 10.0	〔 — 〕 673,300 【 201,990 】	〔 — 〕 2,877	〔 — 〕 8,900
Fostering Joint Interntional Research (B)(*1,3)	〔 — 〕 2,335	〔 — 〕 234	〔 — 〕 10.0	〔 — 〕 673,300 【 201,990 】	〔 — 〕 2,877	〔 — 〕 8,900
Total	〔 101,247 〕 103,672	〔 25,313 〕 25,796	〔 25.0 〕 24.9	〔 64,317,621 〕 62,090,700 【 18,627,210 】	〔 2,541 〕 2,407	〔 141,500 〕 145,100

Notes:
1. "Specially Promoted Research", "Scientific Research on Innovative Areas (Research in a proposed research area)", "Scientific Research" (excluded Generative Research Fields), "Challenging Research" (excluded Generative Research Fields Review Divisions), "Young Scientists", "Research Activity Start-up", and "Fund for the Promotion of Joint International Research (Fostering Joint International Research(B))" are listed.
2. The figures in 〔 〕 indicate the previous fiscal year.
3. The figures in 【 】 indicate indirect costs (excluded from the total).
4. Except for "Challenging Research" which adopts research projects in line with the objectives of the research category regardless of the new adoption rate of policy goal 30%, the new adoption rate is 26.7%.
5. (*1)As these grants are covered under the Multi-year Fund, the columns “Amount allocated" and “Amount allocated per project" are calculated based on the projects' initial plans for FY 2018.
6. (*2)No new invitation for applications is conduted for FY2018.
7. (*3)New invitation for application has started from FY2018.
8. Due to rounding off, the total and breakdown figures may not agree.

(2) New and Ongoing Projects

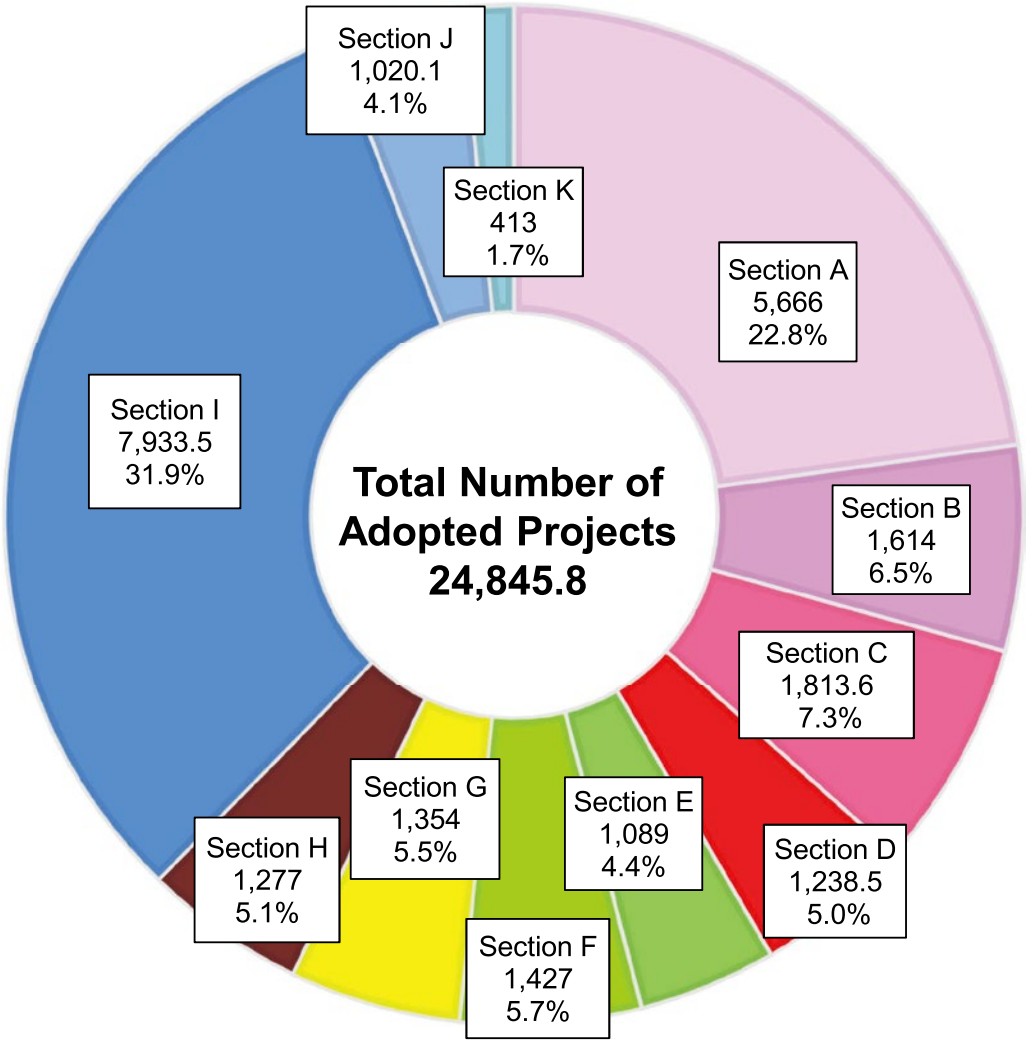
As of October 2018

Research category	Number of proposed projects		Applications allocated	Amount allocated per project	
	Applications	Applications approved		Average	Maximum
			Thousands of Yen	Thousands of Yen	Thousands of Yen
Grants-in-Aid for Scientific Research	〔 151,734 〕 **150,916**	〔 75,563 〕 **74,861**	〔 162,824,914 〕 **162,277,303** **【 48,683,191 】**	〔 2,155 〕 **2,168**	〔 172,000 〕 **162,400**
Specially Promoted Research	〔 166 〕 **160**	〔 68 〕 **67**	〔 5,558,200 〕 **5,447,500** **【 1,634,250 】**	〔 81,738 〕 **81,306**	〔 172,000 〕 **162,400**
Scientific Research on Innovative Areas (Research in a proposed research area)	〔 7,555 〕 **7,741**	〔 2,643 〕 **2,594**	〔 21,799,821 〕 **21,749,272** **【 6,524,782 】**	〔 8,248 〕 **8,384**	〔 129,100 〕 **139,400**
Scientific Research	〔 87,530 〕 **91,892**	〔 48,119 〕 **49,292**	〔 101,986,403 〕 **104,598,250** **【 31,379,475 】**	〔 2,119 〕 **2,122**	〔 94,600 〕 **105,100**
Scientific Research (S)	〔 990 〕 **1,045**	〔 425 〕 **421**	〔 12,050,100 〕 **12,075,400** **【 3,622,620 】**	〔 28,353 〕 **28,683**	〔 94,600 〕 **105,100**
Scientific Research (A)	〔 4,167 〕 **4,063**	〔 2,220 〕 **2,202**	〔 18,471,700 〕 **18,879,700** **【 5,663,910 】**	〔 8,321 〕 **8,574**	〔 32,000 〕 **32,900**
Scientific Research (B) (*1)	〔 17,752 〕 **18,059**	〔 9,393 〕 **9,402**	〔 33,080,533 〕 **35,319,050** **【 10,595,715 】**	〔 3,522 〕 **3,757**	〔 13,500 〕 **12,800**
Scientific Research (C) (*2)	〔 64,621 〕 **68,725**	〔 36,081 〕 **37,267**	〔 38,384,070 〕 **38,324,100** **【 11,497,230 】**	〔 1,064 〕 **1,028**	〔 3,400 〕 **3,200**
Challenging Exploratory Research (*2,3)	〔 4,949 〕 **1,472**	〔 4,949 〕 **1,472**	〔 4,590,400 〕 **1,049,500** **【 314,850 】**	〔 928 〕 **713**	〔 2,300 〕 **1,900**
Challenging Research	〔 15,607 〕 **14,305**	〔 1,680 〕 **3,179**	〔 4,413,700 〕 **7,259,900** **【 2,177,970 】**	〔 2,627 〕 **2,284**	〔 16,200 〕 **17,500**
Challenging Research (Pioneering)	〔 1,116 〕 **917**	〔 94 〕 **176**	〔 643,900 〕 **1,102,400** **【 330,720 】**	〔 6,850 〕 **6,264**	〔 16,200 〕 **17,500**
Challenging Research (Exploratory) (*2)	〔 14,491 〕 **13,388**	〔 1,586 〕 **3,003**	〔 3,769,800 〕 **6,157,500** **【 1,847,250 】**	〔 2,377 〕 **2,050**	〔 4,700 〕 **4,500**
Young Scientists (*2,4)	〔 — 〕 **20,369**	〔 — 〕 **6,256**	〔 — 〕 **8,273,100** **【 2,481,930 】**	〔 — 〕 **1,322**	〔 — 〕 **3,100**
Young Scientists (A) (*1,3)	〔 2,874 〕 **980**	〔 1,459 〕 **956**	〔 6,878,400 〕 **3,675,917** **【 1,102,775 】**	〔 4,714 〕 **3,845**	〔 18,100 〕 **13,200**
Young Scientists (A) (*2,3)	〔 28,353 〕 **9,302**	〔 14,875 〕 **9,270**	〔 15,823,970 〕 **8,424,400** **【 2,527,320 】**	〔 1,064 〕 **909**	〔 3,200 〕 **2,600**
Research Activity Start-up	〔 4,700 〕 **4,695**	〔 1,770 〕 **1,775**	〔 1,774,020 〕 **1,799,463** **【 539,839 】**	〔 1,002 〕 **1,014**	〔 1,500 〕 **1,500**
Fund for the Promotion of Joint International Research	〔 — 〕 **2,335**	〔 — 〕 **234**	〔 — 〕 **673,300** **【 201,990 】**	〔 — 〕 **2,877**	〔 — 〕 **8,900**
Fostering Joint Interntional Research (B) (*1,3)	〔 — 〕 **2,335**	〔 — 〕 **234**	〔 — 〕 **673,300** **【 201,990 】**	〔 — 〕 **2,877**	〔 — 〕 **8,900**
Total	〔 151,734 〕 **153,251**	〔 75,563 〕 **75,095**	〔 162,824,914 〕 **162,950,603** **【 48,885,181 】**	〔 2,155 〕 **2,170**	〔 172,000 〕 **162,400**

Notes:
1. This chart combines the figures for newly selected and continuing projects.
2. "Specially Promoted Research", "Scientific Research on Innovative Areas (Research in a proposed research area)" (excluded Platforms for Advanced Technologies and Research Resources), "Scientific Research" (excluded Generative Research Fields), "Challenging Exploratory Research", "Challenging Research" (excluded Generative Research Fields Review Divisions), "Young Scientists", "Research Activity Start-up", and "Fund for the Promotion of Joint International Research (Fostering Joint International Research(B))" are listed.
3. The figures in 〔 〕 indicate the previous fiscal year.
4. The figures in 【 】 indicate indirect costs (excluded from the total).
5. (*1)Amomg these projects, there are projects selected in from FY2013 to FY2014 that are partially covered under the Multi-year Fund; their columns “Amount allocated per project” are calculated based on the projects' initial plans for FY 2018.
6. (*2)As these grants are covered under the Multi-year Fund, the columns “Amount allocated" and “Amount allocated per project" are calculated based on the projects' initial plans for FY 2018.
7. (*3)Only continuing projects are included.
8. (*4)New invitation for application has started from FY2018.
9. Due to rounding off, the total and breakdown figures may not agree.

5. Chart for the Budget by Research Section (FY2018)

New Projects



Notes:
1. For Medium-sized and Basic Sections where there are multiple corresponding Broad Section, the number of adopted cases and the allocated amount are apportioned proportionally.
2. "Specially Promoted Research", "Scientific Research on Innovative Areas (Research in a proposed research area)" (planned research or invited research), "Scientific Research" (excluded Generative Research Fields), "Challenging Research" (excluded Generative Research Fields Review Divisions), "Young Scientists", and "Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))" are included. ("Research Activity Start-up" is not included because the review is performed by individual review section.)
3. Due to rounding off, the total and breakdown figures may not agree.

Inquiries:

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