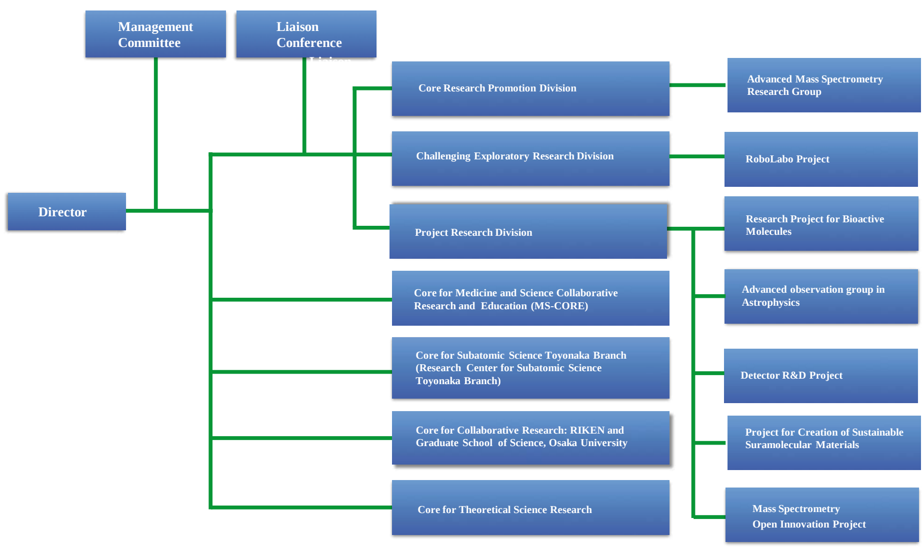
Project Research Center for Fundamental Sciences

Project Research Center for Fundamental Science

Overview

The Graduate School of Science at Osaka University is responsible for carrying out fundamental scientific research. In the spirit of the first president of Osaka University, Dr. Hantaro Nagaoka, whose motto was "Souhaku wo Namuru Nakare (Lack not in originality)" it is dedicated to the discovery of new insights and the development of new perspectives on matter. Our research programs also aim to foster young researchers, who will serve as the next generation of researchers in fundamental science and as internationally active leaders across many fields. The primary research style of the Graduate School of Science is thus to advance fundamental research with a long-term vision through the free thought and creativity of the individual. Research projects demonstrating major findings and showing great promise for future breakthroughs are awarded large-scale competitive funding. However, such large-scale research projects require short-term investments in people, facilities, and time as well as rapid implementation. Although this mode of research can certainly open a path to continuing the development of fundamental science, it is does not fit the traditional research style of the Graduate School of Science. Therefore, The Project Research Center for Fundamental Sciences was established on October 1, 2011 to serve as a facility for large-scale research projects and other efforts, with open laboratories and specialized environments for working with radiation. Large-scale projects and interdisciplinary research in progress at this center have brought about remarkable advances in collaboration with ERATO, ImPACT, and medical research under projected budgetary allocations, as well as the establishment of an international therapeutic base for the treatment of advanced cancer.

The Project Research Center for Fundamental Sciences was reorganized on July 1, 2015 to strengthen its engagement in highly challenging and creative research, education leading to germinal research, the creation of new research and development sectors through new collaborations, and strengthening of industrial-academic co-creation, as well as the advancement of large-scale research projects. With this re-organization, mid- and long-term projects will be carried out by the Graduate School of Science led "Core Research Promotion Division", while "Challenging Exploratory Research Division" was constructed and established as a new framework for engaging in challenging exploratory research. New centers of excellence were also established to facilitate the freedom of growth for research that extends across organizations and institutions. In this way, the Project Research Center is enhancing its platform for advancing cutting-edge research and providing an environment for carrying out original and creative fundamental research at a level worthy of consideration for future Nobel prizes.



Project Research Center for Fundamental Sciences

Project Research Center for Fundamental Science

Faculty Members:

Director[Professor] Koichi FUKASE
Vice Director[Professor] Masahiro UEDA(Fbs), Michisato TOYODA

Core Research Promotion Division

Division Head[Professor] Michisato TOYODA

Advanced Mass Spectrometry Research Group
[Professor] Michisato TOYODA, Masaaki ASHIDA(Es), Kunio AWAZU(Eng), Masahiro UEDA(Fbs), Yasuo KANEMATSU, Toshifumi TAKAO(Protein), Hitoshi TANAKA(Law), Kentaro TERADA(Grad), Koichi FUKASE(Grad), Shinya MURAKAMI(Dent), Taku YAMANAKA(Grad)
[Associate Professor] Morio ISHIHARA(Grad), Osamu HISATOMI(Grad), Hiroshi FURUTANI(Reno),Shoichiro YOKOTA(Grad)
[Assistant Professor] Jun AOKI, Yosuke KAWAI(Grad), Noriko NAKAYAMA(Grad)

Challenging Exploratory Research Division

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[Professor] Yasuo KANEMATSU, Michisato TOYODA, Masahiro UEDA(Fbs),Nohiro MATSUMURA(Eco)
[Guest Professor] Kazuyoshi ITO, Tetsuro KOBAYASHI, Hiroyasu NAKATA, Masaaki YOKOYAMA
[Guest Associate Professor] Yasuhiro TACHIBANA

RoboLabo Project
[Professor] Yasuo KANEMATSU, Michisato TOYODA, Masahiro UEDA（Fbs）
[Guest Associate Professor] Yasuhiro TACHIBANA

Project Research Division

[Division head] Michio MURATA(Grad)

Research Project for Bioactive Molecules
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[Associate Professor] Kazuya KABAYAMA(Grad)
[Assistant Professor] Yoshiyuki MANABE(Grad)
[Specially Appointed Assistant Professor] Yuichi UMEGAWA(Grad)

Advanced observation group in Astrophysics
[Professor] Hironori MATSUMOTO(Grad), Hiroshi SHIBAI(Grad), Takahiro SUMI(Grad)
[Associate Professor] Kiyoshi HAYASHIDA(Grad)
[Assistant Professor] Hirofumi NODA(Grad),Taro MATSUO(Grad)

Detector R&D Projec
[Professor] Taku YAMANAKA(Grad), Hiroshi SHIBA(Grad), Michisato TOYODA , Hironori MATSUMOTO(Grad)
[Associate Professor] Hajime NANJO(Grad)
[Assistant Professor] Jun AOKI, Minoru HIROSE(Grad)

Project for Creation of Sustainable Suramolecular Materials
[Professor] Tadashi INOUE(Grad), Sadahito AOSHIMA(Grad), Katsumi IMADA(Grad), Kiyotaka ONITSUKA(Grad), Takahiro SATO(Grad), Yoshinori TAKASHIMA(Accs), Akihito HASHIDZUME(Grad), HiroyasuYAMAGUCHI(Grad)
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JEOL YOKOGUSHI Research Alliance Laboratories
Mass Spectrometry Open Innovation Project
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[Specially Appointed Researcher] Junichi OSUGA
[Guest Associate Professor] Yoshihisa UEDA
[Visiting Academic Staff] Takaya SATOH

Core for Medicine and Science Collaborative Research and Education (MS-CORE)

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[Professor] Atsushi SHINOHARA(Grad), Hidenori INOHARA(Med), Masahiro UEDA(Fbs), Kazuhiko OGAWA(Med), Yasuhiro KAJIHARA(Grad), Yoshikatsu KANAI(Med), Yasufumi KANEDA(Med), Michisato TOYODA, Takashi NAKANO(RCNP), Masaharu NOMACHI(Irs), Koichi FUKASE(Grad), Mitsuhiro FUKUDA(RCNP), Michio MURATA(Grad),Hiroyasu YAMAGUCHI(Grad), Takashi YOSHIMURA(RI)
[Endowed Chair Professor] Eku SHIMOSEGAWA(Med）
[Specially Appointed Professor] Atsushi TOYOSHIMA(Irs), Jun HATAZAWA(RCNP)
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[Lecturer] Yoshitaka KASAMATSU(Grad), Hiroki KATO(Med), Hiroki KANDA (RCNP),Toru TAKANO(Med), Mitsuaki TATSUMI(Med), Tetsuhiko YORITA(RCNP),
[Assistant Professor] Atsushi SHIMOYAMA(Grad),Tomokazu SUZUKI(RCNP), Yukiko NAKATA(Med), Kojiro NAGATA(Irs),Yoshiyuki MANABE(Grad),Tadashi WATABE(Med)
[Specially Appointed Assistant Professor] Kazuhiro OOE(Med), Yuichiro KADONAGA(Irs), Keisuke TAMARI(Med)
[Endowed Chair Assistant Professor] Keiko MATSUNAGA(Med)
[Specially Appointed Researcher] Takahiro TERAMOTO(Irs)

Core for Subatomic Science Toyonaka Branch (Research Center for Subatomic Science Toyonaka Branch)

[Division head] Masaharu NOMACHI(Irs)
[Professor] Masaharu NOMACHI(Irs), Yoshitaka KUNO(Grad)
[Specially Appointed Professor] Tadafumi KISHIMOTO(RCNP)
[Associate Professor] Masaharu AOKI(Grad), Shuhei AJIMURA(RCNP), Atsushi SAKAGUCHI(Grad), Tatsushi SHIMA（RCNP), Sei YOSHIDA(Grad)
[Assistant Professor] Akira SATO(Grad), Yorihito SUGAYA(RCNP), Keiji TAKAHISA(RCNP)

Core for Collaborative Research: RIKEN and Graduate School of Science, Osaka University

[Division head] Yasuhiro KAJIHARA(Grad)
[Professor] Yasuhiro KAJIHAR(Grad), Takuji OGAWA(Grad), Takashi KUBO(Grad), Koichi FUKASE(Grad), Michio MURATA(Grad), Hiroyasu YAMAGUCHI(Grad)
[Lecturer] Ryo OKAMOTO(Grad)
[Assistant Professor] Yuta MAKI(Grad)
[Guest Professor] Fumiaki HAYASHI(RIKEN)

Core for Theoretical Science Research

[Division head] Koji HASHIMOTO(Grad)
[Professor] Koji HASHIMOTO(Grad), Tetsuo OGAWA(Grad), Hikaru KAWAMURA(Grad), Kentaro NAGAMINE(Grad), Atsushi HOSAKA(RCNP)
[Associate Professor] Koichi FUJIMOTO(Grad)

(Accs)….	Concurrent post belonging to Institute for Advanced Co-Creation Studies
(Dent)….	Concurrent post belonging to Graduate School of Dentistry
(Es) ……	Concurrent post belonging to Graduate School of Engineering Science
(Eng)……	Concurrent post belonging to Graduate School of Engineering
(Eco) ….	Concurrent post belonging to Graduate School of Economics
(Fbs) ……	Concurrent post belonging to Graduate School of Frontier Biosciences
(Grad) ….	Concurrent post belonging to Gradate School of Science
(Irs) ……	Concurrent post belonging to Institute for Radiation Sciences
(Law) ….	Concurrent post belonging to Graduate School of Law and Politics
(Med) ….	Concurrent post belonging to Graduate School of Medicine
(Protein) ..	Concurrent post belonging to the Insritute for Protein Research
(RCNP) ..	Concurrent post belonging to the Research Center for Nuclear Physics
(Reno) ….	Concurrent post belonging to the Center for Scientific Instrument Renovation and Manufacturing Support
(RI) ……	Concurrent post belonging to the Radioisotope Research Center
(RIKEN) ..	Concurrent post belonging to the Institute of Physical and Chemical Research
(Isir) ……	Concurrent post belonging to the Institute of Scientific and Industrial Research

Home Page

http://www.prc.sci.osaka-u.ac.jp/en/

Project Research Center for Fundamental Sciences

Advanced Mass Spectrometry Research Group

Research Themes

1.Development of the most advanced mass spectrometers
2.Interdisciplinary research using the developed mass spectrometers

The division aims at new interdisciplinary research beyond the framework of major disciplines, departments, or universities. The Graduate School of Science created Japan's first mass spectrometer apparatus in the latter half of the 1930s, and has continued since that time in developing a number of globally leading and original spectrometers. In particular, the multi-turn time-of-flight mass spectrometer (MULTUM) developed recently represents a compact apparatus that nonetheless is capable of an extremely high mass resolution. The MULTUM signifies an opportunity for on-site high-resolution mass spectrometry, previously an impossibility. Scientists across the globe look forward to tremendous advancements in this undeveloped domain.

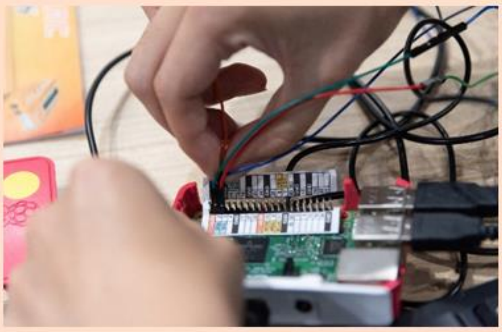
The Division of Interdisciplinary Science develops compact, lightweight, original mass spectrometers and associated technologies for purposes of greenhouse gas monitoring, detection of hazardous or illegal substances, medical diagnostics, deployment to planetary probes, etc.; leads interdisciplinary research across different fields of research through collaborative efforts among division members, faculty members belonging to the Graduate School of Science, researchers at other departments or other universities, and industry; and aims to promote new scientific inquiry.

Project Research Center for Fundamental Sciences

RoboLabo Project

This was launched in fiscal year 2018 as a pilot project to strengthen the appeal and fascination of basic science. This project heightens equipment development skill through collective prototyping of leading-edge equipment, instruments, and systems, and forms the basis for research rising to high challenges.

Interpersonal succession within the laboratory was formerly practicable for electronic circuit technology, high- and low-temperature technology, vacuum technology, machine engineering and construction, program development, and other fields of technology but has now become difficult. The objective is therefore to revive the transfer through incorporation of modern manufacturing methods.



This project fabricates the RoboLabo prototypes such as development of on-site environment analysis robots, planetary probes, mobile labs, remote labs, and other systems. Undergraduate and graduate students develop independence, perform discussion, form a specific image of actual machines, and gather information on required technologies. Learning of technologies in theory and practice grows not only through written characters and diagrams in books and on the Internet but also through interaction with experts including faculty, company researchers, and engineers.

Discipline and vying to meet goals are learned while overcoming failures and discovering the enjoyment of actual machine construction. Enthusiasm brings growth and leads to formation of the base for independent learning.

Project Research Center for Fundamental Sciences

Project for Construction and Function of Innovative Supramolecular Materials

Realizing Supramolecular Materials with High Toughness and Self-Healing Properties
Creation of New Functional Materials

Soft materials such as synthetic polymers, biopolymers, liquid crystals, and molecular assemblies have been widely used in our daily life. Development of new functional soft materials are still desired for constructing mechanical equipment and electric devices with keeping our environment.

In this project, we develop a new type of tough polymer by introducing "*molecular recognition crosslinking*" to polymer networks. These junctions work as a reversible bonding points for self-healing and avoiding the stress concentration. Tough polymers are the prerequisite and promised material for light-weight, reliable, safe, and sustainable industrial products including next-generation vehicles. Moreover, functionalization of these tough materials, such as responsiveness for external stimuli, also enhances field where the polymeric material play an active part.

Project Research Center for Fundamental Sciences

Research Project for Bioactive Molecules

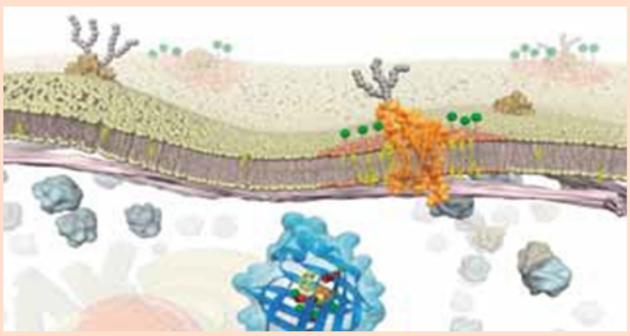
Research Area

1)Elucidation on membrane lipid structure which affects the structure and function of membrane proteins
2)Analysis of structure and dynamics on biomolecular complexes in a lipid bilayer
3)Construction for molecular basis of mutual interaction of lipid ligands and soluble proteins

Research Activities

Lipids are a main component of the biomembranes. The membrane lipids have been recently shown to play key roles in cell physiology through interactions with membrane proteins. On the other hand, structural biology, which has greatly accelerated the advance of biosciences, mainly focuses on proteins but little on lipids and lipid ligands. Because, lipids are highly flexible molecules, therefore the elucidation of the 3D structures binding to membrane proteins receptor is extremely difficult even with X-ray crystallography.

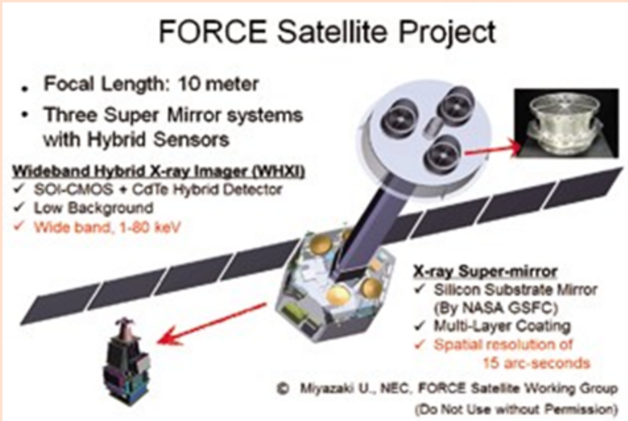
In this project, we will elucidate the active structure of lipids in and around proteins by means of solid-state NMR techniques combined with X-ray crystallography, organic synthesis and protein engineering. Function of lipids will be more profoundly understood in terms of their 3D structures. This breakthrough will advance our knowledge in biological and biomedical sciences over the next decade, thus eventually stimulating research and development in medical and pharmaceutical areas.



Project Research Center for Fundamental Sciences

Advanced Observation Group in Astrophysics

We are aiming to develop observational instruments by using state-of-the-art technologies and to operate them for actual observations by ourselves. For cosmic X-ray observation, we are developing a new X-ray CCD camera for the next X-ray satellite following to the Hitomi Satellite. In parallel of this, together with domestic institutions as well as with NASA Goddard Space Flight Center, we are advancing the FORCE project, which will be able to observe high-energy X-rays with high spatial resolution. One of the main subjects is to elucidate the origin of the cosmic X-ray background radiation to understand the growth mechanism of massive black holes. In the field of infrared astronomy, we are leading the SPICA project, a Japan-Europe collaborative infrared space telescope with many countries/regions. We also lead the Japanese contribution to the WFIRST project of NASA. These projects are pursuing to investigate the formation histories of galaxies, stars, and planets after the Big-Bang of the universe. In addition to them, we are studying on small-scale satellites as well as balloon-borne telescopes that can be executed by ourselves only. These smaller projects enhance the frequency of research projects. Actually, we will launch FITE (Far-infrared Interferometric Telescope Experiment) that has the highest spatial resolution in the far-infrared region. It is a unique project, and is expected to image the distribution of materials around stars. We are also developing a new type of high-angular resolution X-ray imaging instrument which utilizes the Talbot effect.

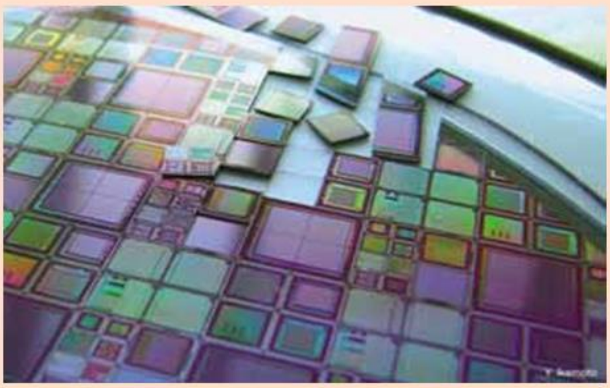


Project Research Center for Fundamental Sciences

Detector R&D Project

The detector technologies are crucial in modern physics experiments. In particle physics, radiation-hard semi-conductor detectors with very fine position resolution, and photon detectors with extremely low inefficiency are often required. In astrophysics, detectors and electronics on satellites are required to have light weight, low energy consumption, and radiation hardness. The detector used in infrared astronomy needs an ASIC that can be operated in ultra low temperature. In mass spectroscopy, semi-conductor detectors are being considered.

We plan to study and develop common basic technologies, and then apply them to cutting-edge detectors for each application in various fields, such as experimental particle physics, astrophysics, mass spectroscopy, and imaging in chemistry and biology.



Project Research Center for Fundamental Sciences

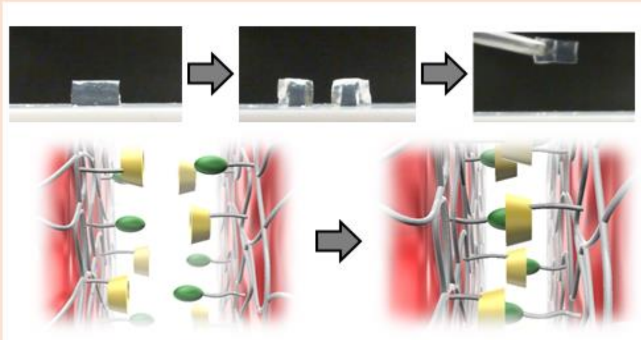
Project for Creation of Sustainable Supramolecular Materials

Realizing High Toughness and Self-Healing of Polymers by Supramolecular Assembly
Creation of New Joining Technology Based on Chemical Bonding

Soft materials such as synthetic polymers, biopolymers, liquid crystals, and molecular assemblies have been widely used in our daily life, and modification of these soft materials and development of new functional soft materials are still desired. New types of gels have been developed, for example, stimulation-responsive gels, self-healing gels and so on.

In this project, we develop a new type of tough polymer by introducing "*molecular recognition crosslinking*" or "*molecular mechanical crosslinking*" in polymer networks. These junctions can work as a well-controlled self-healing point and a pulley effective for avoiding the stress concentration, respectively. Tough polymers are the prerequisite and promised material for light-weight, reliable, safe, and sustainable industrial products including next-generation vehicles.

Adhesives have been widely used to glueing components of product. However, the adhesives have some weak points in toughness and durability for organic solvents. We develop a new material joining technique by introducing covalent bonds between dissimilar materials without using adhesives. We are also studying new adhesive techniques based on molecular recognition, which make it possible to adhere the components with distinguishing their materials.



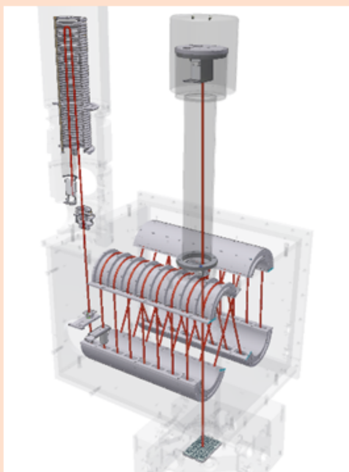
Project Research Center for Fundamental Sciences

JEOL YOKOGUSHI Research Alliance Laboratories
Mass Spectrometry Open Innovation Project

A new research laboratory has been established by JEOL Ltd. and Osaka University in the Graduate School of Frontier Biosciences, as an Osaka University Collaborative Research Center system in a development involving the cancellation and reorganization of the Mass Spectrometry Open Innovation Joint Research Chair first launched in April 2017. The project began in April as the Mass Spectrometry Open Innovation Project of the Graduate School of Science Project Research Center for Fundamental Science in the JEOL YOKOGUSHI Research Alliance Laboratories. In addition to mass spectrometric research, its mission includes the development of new fields of application in conjunction with electron microscopy, nuclear magnetic resonance, and other JEOL core technologies.

The project will advance the development of technologies and applications relating to mass spectrometry as the core of this industry–university collaboration effort, which will bring together researchers and companies from multiple fields. The project will engage in themes ranging from medical, dental, and pharmaceutical science to the environmental and other sectors. The project will form a wing of the JEOL YOKOGUSHI Research Alliance Laboratories and advance cross-sectoral research.

The basic research and development theme in this project is the development of an onsite periodontal disease diagnosis system and method. Concurrently with the development of a method that enables analysis in a shorter time, the project is engaged in the development of metabolite analysis technology to facilitate identification of the basal pathophysiology. The project is also developing new technology for ionization and cell detection and identification, and a method of particulate matter $PM_{2.5}$ analysis. In parallel with its research and development, the laboratory is engaged in promoting basic technology succession and in human resource development and cultivation.



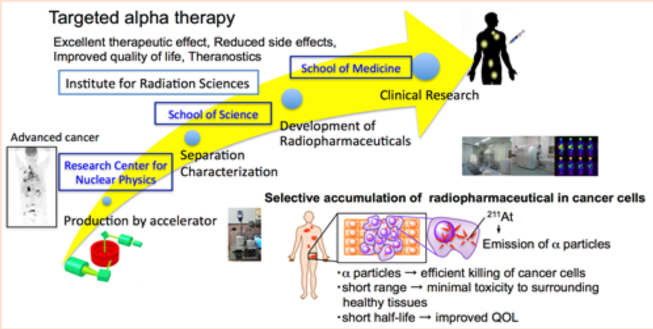
Ion optical system of JMS-S3000 at market launching, which applies the ion optical system of the MULTUM developed at Osaka University.

Project Research Center for Fundamental Sciences

Core for Medicine and Science Collaborative Research and Education (MS-CORE)

Project Overview

Joint research on production and medical applications of radionuclides using the accelerator is conducted with the cooperation of Graduate School of Science, Research Center for Nuclear Physics, and Graduate School of Medicine. Since Osaka University established the Institute for Radiation Sciences (IRS) on April 1, 2018 to promote research and education in radiation sciences, MS-core has collaborated with IRS to promote the interdisciplinary researches between nuclear physics, nuclear chemistry, biomolecular chemistry, nuclear medicine, and radiology. The development of new cancer treatments has been desired, since one-third of cancer patients are diagnosed as progressive cancers such as adjacent organ invasion and distant metastasis at the time of initial diagnosis, and therefore the 5-year relative survival rate are less than 15%. In this project, we will develop a new internal radiotherapy for advanced cancer, i.e., "targeted α-particle radiotherapy" where cancer patients are treated by irradiating the α ray to cancer by administrating cancer-targeting agents tagged with α-emitting radionuclides. This therapy will achieve the high cancer cell-killing ability as well as the less invasiveness to peripheral organs and the reduction of side effects at the same time, owing to the high-energy and the short flight of α ray and the short-lives of α-emitting radionuclides. In order to develop this therapy, we are working on the development of skeleton cyclotron that can produce the high beam intensity with power-saving property as well as the development of the large quantity production α-emitting radionuclides and the automatic separation of the radionuclides. Further, we are studying the synthesis of the radionuclide-carrying targeting agents as the radiation drug candidates, verifying the therapeutic effects and side effects of the agents, and investigating the clinical trials of the



Project Research Center for Fundamental Sciences

Core for Subatomic Science Toyonaka Branch

(Research Center for Subatomic Science)

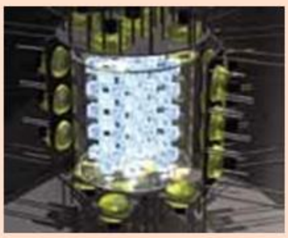
Subatomic Science is subject to study the early Universe before it became transparent to radiation. In Project Research Center for Fundamental Sciences, Lepton physics in Subatomic Science is studied.

MUSIC

Why there are three kinds of quarks and lepton existing in nature and why are they transformed from one to another ? It is one of the mysteries, which should be answered by elementary particle physics. In order to answer this question, physics phenomena which cannot be explained by the Standard Model of particle physics are seemed for with using muons. To do these searches, many muons are needed. At the MuSIC facility, we are expecting a number of muons of 108-9/second with 400 Watts proton beam power from the RCNP cyclotron. It is one of the highest intensity muon beam in the world.

CANDLES

Our universe is made of matter and no anti-matter exists. In order to explain why, we need to show that particle number violation and CP violation. The CP violation indicates that matter world and anti-matter world is different a little bit. By the observation of neutrino-less double beta decay of ^{48}Ca, we wish to demonstrate the violation of particle number is violated and our universe was inclined to matter world.



Project Research Center for Fundamental Sciences

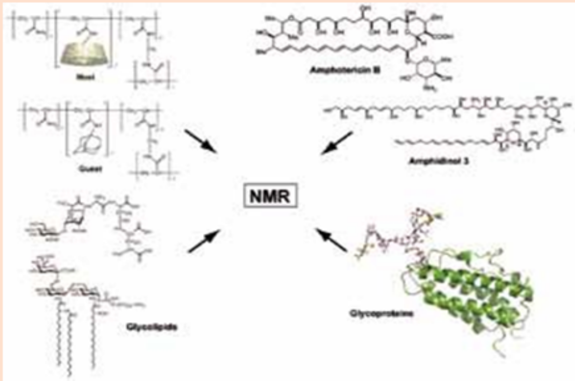
Core for Collaboration Research : Riken and Graduate School of Science, Osaka University Group

Research Topics

1.Studies of host-guest interaction by means of nuclear magnetic resonance (NMR)

2.Studies of structural analyses as well as molecular dynamics of lipids, glycolipids, and glycoproteins by means of NMR

This project examines frontier scientific researches by combining both techniques accumulated in Riken and graduate school of science, Osaka University. Riken has developed a huge frontier NMR facility in Yokohama and elucidated many protein structures. These results have been applied not only to the elucidation of protein functions but also to basic researches and the development of pharmaceutical drugs. Researchers in graduate school of science, Osaka University have demonstrated isolation, chemical syntheses and structural analyses of valuable natural molecules and novel functional derivatives, e.g. specific binding experiments between novel macromolecular gels modified with unique host and guest molecules, syntheses of glycolipids concerned with our immune system, antibiotics interacting with cell lipid bilayer and glycoproteins. The collaboration of Riken's NMR techniques and chemical approaches by graduate school of science, Osaka University will open up a new avenue to elucidate the functions and molecular dynamics of natural and new functional compounds in detail.



Project Research Center for Fundamental Sciences

Core for Theoretical Sinence Research

Any theoretical science is based on equations and mathematical structure, which are universal and are a basis of any scientific research. On the other hand, because of the intense subdivision of scientific research subjects of recent years, unfortunately communication among different research area is missing.

The project members try to overcome this serious problem which resides in any department in Osaka unviersity, and in particular using theoretical common background may help resolving the issue, we expect. This simple project in fact should create a seed of new sciences, and will promote the total atmosphere of science research in Osaka university to an upper level.

We first start a theoretical colloquia with which we put a basis of opportunities for researchers to come and see each other, to start with. The colloquium is named "Nambu colloquium" where we obtained the renowned name of a distinguished professor in Osaka unvieristy, Yoichiro Nambu, a Nobel loreate. A successful organization of the colloquia should be the first ground for the promotion of research in Osaka unviersity.