### Division of Science (Physics)

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*Current as of March 31, 2009*
Division of Science (Physics)

*Professor Takashi Omori

- **Area and Subject Taught**: Energy, Environmental Science
- **Research Theme(s)**: Using Electrochemical Technology to Address Environmental Problems
- **Academic Degrees**: Doctor of Engineering, University of Tokyo
- **Keywords for Research Field**: Environment, Energy, Global Warming, Electrochemistry
- **Office Phone Number**: 81-75-705-1860
- **E-mail**: tohmori@cc.kyoto-su.ac.jp

[Research Overview]

Environmental pollution is worsening on the global level, and environmental problems have become the number one issue for modern science and society. The problem of global warming in particular threatens the survival of mankind and other living things, and must be solved through the collective wisdom of all people. We are conducting research on topics that can help prevent global warming and solve our energy problems. Specific topics include hydrogen production from solar electrolysis of water, developing technology for electrochemical reduction, fixation and effective utilization of CO₂, and hydrogen storage technology.

Diverse and active R&D is being carried out on hydrogen, a form of green energy that can replace fossil fuels. A key point is where to get the supply of hydrogen: producing it with renewable energy will reduce CO₂ emissions. We are focusing our R&D efforts on a distributed hydrogen production system employing sunlight, and our aim is to meet energy demands through on-site production, with zero emissions of CO₂.

[Notable Publications and Works in the Last Three Years]

5) スルーホールが形成された導電膜およびその製造方法、立川健二郎、辻克之、水井総一、大森隆、特願2004-068251。
6) 太陽光を利用した水素の製造方法及び太陽光を利用した水素の製造装置、松木伸行、山田羊治、大森隆、豆塚廣章、鈴木栄二、近藤道雄、松田彰久、特願2002-89884。
7) 光触媒による水からの水素製造技術の最新動向、大森隆（分担執筆）、シーエムシー出版、(2003)。
8) 分散型太陽光水素製造、大森隆、高圧ガス 40, 16 (2003).
Division of Science (Physics)

* Professor Kenji Okada

- **Area and Subject Taught**: Nuclear Spectroscopy
- **Research Theme(s)**:
  - Development of a Four-Dimensional Topological Counter Test of QCD by Measuring Lifetime of the $\pi^+ \pi^-$ Atom
- **Academic Degrees**: Doctor of Science, Osaka University
- **Keywords for Research Field**:
  - Topological Triggers, Scintillating Fiber (SciFi) Hodoscopes, Lifetime Measurement of Mesonic Atoms
- **Office Phone Number**: 81-75-705-1950
- **E-mail**: okada@cc.kyoto-su.ac.jp

[Research Overview]

A Four-dimensional topological trigger detector is an electronic device providing three dimensional position and a time information of two or more particles, and giving distances among those particles. It is used to generate trigger signals for data taking in nuclear physics experiments. The device consists of a detector composed of thin scintillating fibers with a diameter of 0.25-0.5 mm, a readout composed of position sensitive photomultipliers and digitization circuits of newly developed peak sensing circuits and trigger logic circuits. Since 1999, we have been continuing an experiment at the European Organization for Nuclear Research (CERN: PS212: DIRAC) to test the quantum chromodynamics (QCD) at a low energy region using the above device as the central trigger detector. This is a challenging and difficult experiment where we produce mesonic atoms from $\pi^+$ and $\pi^-$ mesons, and measure precisely its decay lifetime of an order of $10^{-15}$ seconds. From 2006 to 2009 as a second stage of the DIRAC experiment, we have been measuring the lifetime of $\pi$ -K atoms.

(http://www.cern.ch/DIRAC/)

[Notable Publications and Works in the Last Three Years]

1) Evidence for $\pi$K-atoms with DIRAC.
   The DIRAC collaboration, Phys, Letters B674 (2009) 11-16

2) High resolution scintillating-fibre hodoscope and its readout using Peak-sensing algorithm.

3) First measurement of the $\pi^+ \pi^-$ atom lifetime.
Division of Science (Physics)
* Professor Takashi Oshiyama

Area and Subject Taught: Surface Physics
Research Theme(s):
- Super-Lattice Structures of adatoms and Their Electronic States
  — Tensor-LEED and AES Methods —
Academic Degrees: Doctor of Science (Physics), Kyoto University
Office Phone Number: 81-75-705-1632
E-mail: oshiyama@cc.kyoto-su.ac.jp

[Research Overview]
Under flashing at high temperatures (950°C – 1250°C) to remove the oxide layer, the surface of Si(001) becomes a vicinal surface with higher step (defects) density than that of Si(111). But the adatom covered surface will be good heterogenous interface for epitaxy. After deposition of Group V or VI atoms on Si(001) surface, the adatoms and the substrate atoms are rearranged depending on the surface annealing temperature and super-lattice structures (heterogeneous structure) are formed. This adatom-induced surface state is studied by measuring $I$ vs. $V$ curves with the low-energy electron diffraction method. And the analyses of the Auger spectra, i.e. the intensities and profiles, give information on the relaxation phenomena that occur at the surface layer. The Auger transition process, where two holes are localized in the inner shell, has the advantage of easily and clearly capturing relaxation phenomena in experiment in comparison with that of XPS.

This work has significance as basic research for developing new functional films and device materials using the Si-surfaces.

[Activities as Instructor or Student in the Last Three Years (Papers Presented at Academic Conferences and Workshops, etc.)]
The followings are the theses of Graduate Students (in Japanese).
1) Meta-stable structures c(4×4) on Si (100) and Surface Deby-temperature.
2) Multiple scattering effects in the $I$ vs. $V$ curves.
4) Super-Lattice structure for Te-deposted Si (100).
5) Temperature-Dependence of diffraction spots from Si (100).
6) Multiple scattering within a Bravais-Lattice.
Division of Science (Physics)

* Professor Ryoichi Kado

Area and Subject Taught: Magnetic Resonance

Research Theme(s):
- Solid-State NMR, Double Resonance

Academic Degrees:
- Master of Science, Kyoto University

Keywords for Research Field:
- Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR), Double Resonance, Dynamic Nuclear Polarization (DNP)

[Research Overview]
The phenomenon of magnetic resonance occurs due to resonant interaction between the magnetic moments of electrons and atomic nuclei in a material subjected to a magnetic field, and radio waves irradiated onto that material. It is an indispensable technique for research in condensed matter physics, and has been applied to a broad range of fields including chemistry, pharmacology, biology and medicine. Recent applications of magnetic resonance that have garnered attention are MRI (Magnetic Resonance Imaging) and quantum computers, and there is a particularly pressing need for improved sensitivity of nuclear magnetic resonance (NMR). In this laboratory, we are primarily conducting developmental research on experimental techniques for solid-state NMR and double resonance. More specifically, we hope to trigger an effect called dynamic nuclear polarization (DNP)-through double resonance with electron spin resonance (ESR), nuclear quadrupole resonance (NQR), laser-excited ESR or other techniques-and thereby dramatically improve the sensitivity of NMR.

[Notable Publications and Works in the Last Three Years]
Division of Science (Physics)

* Associate Professor Hideyo Kawakita

- **Area and Subject Taught:** Astronomy
- **Research Theme(s):** Chemical evolution of cometary materials in the early Solar System
- **Academic Degrees:** Doctor of Science
- **Keywords for Research Field:** Astronomy, Planetary Science, Solar System, Comets
- **Office Phone Number:** 81-75-705-1612

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**[Research Overview]**

It is thought that our solar system formed from a molecular cloud of gas and dust grains 4.6 billion years ago. Many extra-solar planetary systems have been discovered, and the number of planets in the universe is much greater than previously expected. However, the birth and evolution of these planetary systems are still not adequately understood. What sort of planetary systems are created under what conditions? Even basic points like these are still unclear.

My main research interest is the formation of our solar system. The solar system is the closest object to us, and can be observed in the most detail. However, 4.6 billion years have passed since the formation of our solar system. How can we investigate the environment at the time of the solar system’s formation? Small objects called “primordial objects,” which have undergone almost no change in 4.6 billion years, are crucial for this purpose. My research focuses particularly on comets comprised of ice and dust grains. Comets hold the information about the formation of the solar system, and by investigating their composition and other characteristics, we can obtain formation conditions such as the temperature of the molecular cloud from which the solar system was born.

**[Notable Publications and Works in the Last Three Years]**


4) 宮元、篠、平田、杉田 編、「惑星地質学」、東京大学出版会、(分担執筆)

5) 渡部、井田、佐々木 編、「シリーズ 現代の天文学 9 太陽系と惑星」、日本評論社、(分担執筆)


Division of Science (Physics)

* Professor Shinzo Suzuki

- **Area and Subject Taught:** Molecular Materials Science
- **Research Theme(s):**
  - Physical Chemistry of Carbon Nanostructures
- **Academic Degrees:** Doctor of Science, Kyoto University
- **Keywords for Research Field:**
  - Physical Chemistry, Carbon Nanostructures, Fullerenes, Single-Walled Carbon Nanotubes

[Research Overview]
A variety of carbon-assembled materials, e.g., spherical carbon clusters (fullerenes) such as $C_{60}$ molecule with its soccer-ball structure, and single-walled carbon nanotubes which have the structure of a rolled-up graphite monolayer, can each be regarded as a carbon nanostructure that has its own unique physical and chemical properties. The main aims of our research are to make these materials, and also to purify them in our own laboratory, in order to investigate how their individual geometrical structures are reflected in their physical and chemical properties (electronic states, vibrational structure, solid-state properties, etc.), and also to study the formation process itself, by examining fabrication conditions.

An arc-burning system and a high-temperature laser-vaporization system are currently (as of 2009) available as experimental equipment for making fullerenes and single-walled carbon nanotubes. We investigated the single-walled carbon nanotubes obtained by using the arc-burning method, and we dispersed these carbon nanotubes in a surfactant solution. We investigated the chirality distribution of the individual nanotubes with semiconducting character, by measuring emission-mapping spectra. Our next goal, for 2009 and beyond, is to use both electrophoresis and a centrifugation technique to separate and purify those single-walled carbon nanotubes that have a metallic and semiconducting character. In addition, we also plan to fabricate single-walled carbon nanotubes using porous glass and the CVD technique.

[Notable Publications and Works in the Last Three Years]
Division of Science (Physics)

* Professor Ikuo Sogami

- **Area and Subject Taught:** Elementary Particle Theory
- **Research Theme(s):**
  1. Construction of Gauge Field Theories for Semi-simple Flavor Symmetry Groups
  2. Elucidation of the Accelerating Expansion of the Universe and the Origins of Dark Energy
  3. Deformation Theory of Quantization
- **Academic Degrees:** Doctor of Science, Kyoto University
- **Keywords for Research Field:** Flavor Symmetry, Gauge Field Theories, Generation Structure, Inflation, Dark Energy, Colloids
- **Office Phone Number:** 81-75-705-1622
- **E-mail:** sogami@cc.kyoto-su.ac.jp

**[Research Overview]**

It may seem odd to see "research on generation structure" listed as a research topic in high-energy physics. Allow me to explain using a familiar elementary particle, the electron, as an example. The electron has two close relatives, the $\mu$ particle and the $\tau$ particle. Amazingly, these close relatives have exactly the same properties aside from their difference in mass. Other elementary particles such as quarks and neutrinos also have a similar triple repeating structure. The question of why nature chose this seemingly pointless triple structure is the heart of the "generation structure problem." I believe that, in an extremely-high-energy scale, there arises a new symmetry among these close relatives (which are called "generations"). Through a process of trial and error over many years, I have found promising leads on how to express this idea in a mathematical system, and currently we are conducting research to perfect the theory. Fortunately, high-energy experiments that can verify the idea will begin in Europe this year. The idea also implies that the differences in generations played an important role up to a certain stage in the evolution of the universe. Our plan is to study the evolution of the universe from the perspective of this theory, and search for the true nature of the dark energy causing the accelerating expansion of the universe.

**[Notable Publications and Works in the Last Three Years]**


**Visiting Professor  Hiroyuki Daido**

- **Area and Subject Taught:** Photon Science
- **Research Theme(s):**
  - Research on Ultra-Intense Lasers: Their Interaction with Matter, and Applications
- **Academic Degrees:** Doctor of Engineering, Osaka University
- **Keywords for Research Field:**
  - Laser Plasma, Laser Accelerators, High Field Science, Photomedicine
- **E-mail:** daido.hiroyuki@jaea.go.jp

**[Research Overview]**

I am studying the relativistic plasmas produced when matter is irradiated with ultrahigh-intensity lasers. Lasers are often regarded as one of the greatest inventions of the 20th century, and the coherent light obtained from laser operation enables generation of light pulses with extremely short duration and high intensity. With a laser pulse width of 10 femtosec and an energy of 1 J, intensity becomes $10^{14}$ W. Although the pulse only lasts for a brief instant, this is $10^8$ times the power produced by a 1 million kW power plant. When such a laser pulse is focused onto matter, it instantaneously turns the matter into plasma (a state where electrons and ions are separated from each other). Interaction with this plasma can be interpreted as a process where the coherent energy of the laser is converted into relativistic motion of electrons in the plasma due to an extremely short and powerful periodic electric field, and the electrons are collectively accelerated in the direction of propagation of the laser light. Therefore, the X-ray emissions and ion/electron beams produced by the plasma are expected to have sharp directionality. Events such as nuclear excitation, nuclear transmutation and pair production occur in large numbers due to the high-energy electrons and hard X-rays (γ-rays) produced, and there is potential for a significant contribution to basic science, including research on physical properties of high energy density states associated with nuclear reactions. On the other hand, with repeated operation, the above physical process can be used as an X-ray or ion source of exceptionally high brightness, and thus is also likely to have practical applications. My research focuses on these ultra-short-pulse, high-intensity lasers, particularly on the physics of their interaction with matter, and their applications.

**[Notable Publications and Works in the Last Three Years]**


Division of Science (Physics)

*Professor Fujio Takeutchi*

- **Area and Subject Taught:** Nuclear Physics
- **Research Theme(s):**
  1. Medium Energy Nuclear Reactions
  2. Test of Non-perturbative QCD by means of the measurement of the Lifetime of Hadronic Atoms
  3. Fast Readout of Scintillating Fibers Using Position-Sensitive Photomultipliers
  4. Applications of High-Energy Physics Technology to the R&D of Medical Imagers
  5. Image Restoration by Blind Deconvolution
- **Academic Degrees:** Doctor of Science, University of Tokyo
- **Keywords for Research Field:** Double Hypernuclei, Test of QCD, Hadronic Atoms, Scintillating Fiber Hodoscopes, PET, Neutron Detectors, Blind Deconvolution
- **Office Phone Number:** 81-75-705-1626
- **E-mail:** takeut@ksuvx0.kyoto-su.ac.jp

[Research Overview]

1. Experimental study of Atomic Nuclei: Atomic nuclei are many-body systems that have been studied for a long time, but there are still many unknowns about their constituent particles as well as interactions between them. With the success of quantum chromodynamics, the current focus of interest is the strong interaction phenomena where the quark degrees of freedom are essential. More specifically, we are conducting (a) research on double hypernuclei, and (b) PS212 (DIRAC) experiment to measure the lifetime of hadronic atoms at CERN.

2. On the other hand, helped by the rapid progress in scintillating fibers, and scintillating crystals, we study the fast read-out of them using the position-sensitive photomultipliers. (1)(b) above, is an experiment made possible by using this device as a topological trigger device. We are also conducting R&D of radiation imagers for medical use using fast readout technologies. Another research area is the image processing using blind deconvolution and other techniques, that aims at improving the quality of image data obtained with the imagers.

[Notable Publications and Works]

2. The DIRAC collaboration; First measurement of the $\pi^+ \pi^-$ atom lifetime, Phys. Letters B **619** (2005) 50-60
4. B. Adeva et al., DIRAC: A high resolution spectrometer for pionium detection, Nucl. Inst. Meth. in Phys. Res. A **515** 467-496
5. H. Takahashi et al., Observation of a $\Lambda\Lambda^6$He double hypernucleus, Phys. Rev. Letters **87** (2001) 212502-1-212502-4
Division of Science (Physics)

* Professor Masayuki Tanikawa

- Area and Subject Taught: Non-Linear Optics
- Research Theme(s):
  - Fundamentals of Spectroscopy, Non-Linear Optical Processes, Optical Crystals, Nanostructures, Organic Semiconductors
- Academic Degrees: Doctor of Science, Kyoto University
- Keywords for Research Field:
  - Laser Spectroscopy, Organic Semiconductors

[Research Overview]
I am investigating fluorescence, wavelength conversion and various other optical properties of crystals containing rare-earth ions, clarifying their characteristics as optical crystals, and pursuing possibilities for opening up new wavebands for optical communication, and applications in wideband optical amplifiers and wavelength-tunable light sources.

Another aim is to develop new spectrometry techniques by elucidating fundamental phenomena: light scattering in photonic crystal nanostructures, non-linear light absorption processes in multilevel atomic systems, and coherent transients such as quantum beats, etc.

I am investigating electro-optical characteristics, including transient response, of elements built with organic semiconductors (e.g., electroluminescence elements, sensors and transistors) based on the optical properties of thin-film materials made from organic semiconductors. In this way, I am pursuing practical development of organic EL color displays, and possibilities such as new sensors and systems for photoelectric conversion.

[Notable Publications and Works in the Last Three Years]
1) Organic LED device based on PtOEP phosphor without doping in host material, Current Applied Physics 5 633-639, 2005
2) New emission band of PtOEP phosphor in organic LED devices, Current Applied Physics 5 47-54, 2005
3) Europium ions in electrolytic colored KClPb$^{2+}$ + Eu$^{2+}$ crystals, 京都産業大学先端科学技術研究所所報5 11-22, 2006
4) Gravitational sedimentation effect of colloidal silica crystals in binary systems of titanium dioxide and silica particles, Phase Transitions 80 p875-886, 2007
Visiting Professor  Keisuke Nagashima

Area and Subject Taught: Photon Science
Research Theme(s):
- Plasma Physics, Laser Optics, X-ray Lasers
Academic Degrees: Doctor of Engineering, University of Tokyo
Keywords for Research Field: Plasma, Lasers, Optics
Office Phone Number: 81-774-71-3341
E-mail: nagashima.keisuke@jae.go.jp

[Research Overview]
Active R&D is underway throughout the world on next-generation coherent X-ray sources, and there are high expectations for applications in an extremely broad range of fields including materials science and the life sciences. X-ray lasers using ultra short pulsed laser technology can be coherent X-ray sources dramatically smaller than beam facilities using an accelerator. This will enable use of coherent X-rays in various fields at laboratory scale. To achieve this, we have developed a small X-ray laser device capable of high repetition operation, and we are conducting research to develop pioneering optical technology for coherent X-rays using this device.

[Notable Publications and Works in the Last Three Years]
1) Efficient electron heating in nitrogen clusters irradiated with intense femtosecond laser pulses  
2) Development of a chirped pulse amplification laser with zigzag slab Nd:glass amplifiers dedicated to x-ray laser research  
3) Bases and applications of surface plasmon  
[Research Overview]

Recently, detailed observations (WMAP) have been made of the spectra of temperature fluctuations in the cosmic background radiation of 3K (2.725 ± 0.002K). As a result, the spectra of density fluctuations in the early universe and the parameters of the universe are now understood with much greater precision (i.e., the age of the universe is 13.7 billion years ± 100 million years; the baryon density is 4% of the density of the universe; dark matter is 23%; and dark energy is 73%). We are carrying out the detailed investigation of how the spectra of density fluctuations in the early universe connect to the observed spectra of temperature fluctuations in the background radiation, and examining the physical processes in the early universe. Our research concerns the various problems of the early universe: expansion of the universe due to inflation from quantum fluctuations, formation of the spectra of density fluctuations due to the end of expansion, variations in spectra due to subsequent growth of fluctuations, formation of galaxies and galaxy clusters due to the non-linear increase of those fluctuations, formation of their large-scale structure, and formation of early stars and planets within galaxies.

Regarding quantum gravity theory, on the other hand, there have been various attempts to integrate macro-gravitational fields and the micro-uncertainty relation in some form, and we are focusing on the thermodynamics (particularly entropy) of black holes, the universe whose expansion is accelerating, and the system being accelerated (Rindler system).

[Notable Publications and Works in the Last Three Years]


[Research Overview]
The macroscopic characteristics (solid state properties) of matter, such as electrical characteristics that distinguish metals and semiconductors, and almost all magnetic properties appearing in magnets, are determined by how the electrons comprising the microscopic world inside matter, and the spins which are their internal degree of freedom, behave as a group. Condensed matter physics is a theoretical system for using quantum mechanics and statistical mechanics to elucidate what is happening in this micro world. In all matter, there are particularly strong interactions between electrons and between spins, and material systems exhibiting distinctive group characteristics with strong mutual effects are called strongly correlated systems. I am conducting theoretical research to determine what new quantum liquids arise in low dimensional systems where correlation effects appear strongly in low-energy physical properties, and what sorts of new, previously unknown physical property possibilities are latently present between the long-distance order and quantum liquid.

[Notable Publications and Works in the Last Three Years]
C. Hotta, F. Pollmann, Dimensional Tuning of Electronic States under Strong and Frustrated Interactions Physical Review Letters, 100, 186404 (2008)
他6件
[Research Overview]
In the 1970s it became known that, of the four forces that act upon elementary particles, the electromagnetic force, the weak interaction, and the strong interaction can be described by means of gauge theory; this has been well verified by experiments. In 2002 it was confirmed that the phenomenon known as breakdown of CP symmetry can be explained in detail using the sextile quark theory proposed jointly by Mr. Kobayashi and myself. The remaining issue would seem to be supersymmetric particles, and it is probably just a matter of time until they are confirmed by experimentation. In fact, though the results of the 2002 experiment are preliminary, the existence of supersymmetric particles has been reported.

Another issue that remains is quantum gravity. String theory and other useful theories have been advanced as approaches, and particle physicists all over the world are competing to find a complete solution. It became clear that Newtonian mechanics cannot be applied to the microworld and objects that move at nearly the speed of light, so it was eventually replaced by new theories that satisfy the requirements of quantum mechanics and relativity theory. I consider quantum gravity to be a problem of space-time in the microworld, and I hope to reconstruct the concept of space-time to satisfy the requirements of this world. I don’t think this problem is a simple one, but as someone who has received a certain amount of public recognition for my work thus far, I think it might be a good idea to try an approach that differs somewhat from the current fashion.

[Notable Publications and Works in the Last Three Years]
出版: 自然の謎と科学の浪漫 (新日本出版社, 2003)
科学にときめく (かもがわ出版, 2009)
**Division of Science (Physics)**

*Professor Shigeru Miyoshi*

- **Area and Subject Taught:** Astrophysics
- **Research Theme(s):**
  - Galaxy Clusters and Dark matter, Quasars, Neutron Stars
- **Academic Degrees:** Doctor of Science, Nagoya University
- **Keywords for Research Field:**
  - Cosmology, Astrophysics, X-ray Astronomy, Dark Matter
- **Office Phone Number:** 81-75-705-1609
- **E-mail:** sjm@gold.ocn.ne.jp

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**[Research Overview]**

I am conducting both observational and theoretical research on problems in cosmology and astrophysics. In my observational work, I am using the X-ray and γ-ray intensity maps and energy spectra of galaxies, galaxy clusters and quasars obtained from Japanese and foreign X-ray and γ-ray astronomy satellites, to investigate the physical structure of those objects. My recent focus has been the dark matter contained in galaxy clusters. In collaboration with the Radio Astronomy Group of the University of Cambridge, UK, I am attempting to measure the Hubble constant using the results of X-ray observations and the results of observing the Sunyaev-Zel’dovich effect on the cosmic background radiation due to high-temperature plasma electrons of galaxy clusters. In my theoretical work, I am exploring the origins of supermassive black holes thought to be at the center of quasars. I am examining the cause of the recently found temperature drop in the central region of galaxy clusters, based on a two-pronged strategy of rethinking the effects of black holes and the thermodynamics of self-gravitating systems. I am also investigating the interaction between the strong magnetic field of rotating neutron star and surrounding matter.

**[Notable Publications and Works in the Last Three Years]**

Division of Science (Physics)

* Professor Hiroshi Yamagami

- **Area and Subject Taught:** Solid-State Electron Theory
- **Research Theme(s):** Theoretical Research on Electronic Structure of Strongly-Correlated f-Electron Systems
- **Academic Degrees:** Doctor of Philosophy, Niigata University
- **Keywords for Research Field:** Solid-State Physics
- **E-mail:** yamagami@cc.kyoto-su.ac.jp

[Research Overview]
Condensed matters are formed by a combination of over 100 types of atoms, and their physical properties are highly diverse: Progress in materials processing technologies has enabled a creation of any artificial materials with useful characteristics, distinctive to natural materials. According to some physical phenomena, the condensed matters are classified as metals, semiconductors, insulators, superconductors, magnets and so on, and the underlying "solid-state physics" is the discipline that theoretically derives these phenomena from the fundamental principles of physics. The quantum mechanics for electronic states in solids is called electronic structure theory or "band theory", existing as the most basic theory of the solid-state physics. The band theory gives first-principles method to calculate the electronic structure, and clearly explains the general classification of materials based on electric conductivity. Moreover, a current band theory must be developed so as to consider a strongly correlated aspect of the electrons in many-electron system, and there are a lot of research issues that need to overcome, including some extensions of the band theory.

In recent years, single-crystal growth of heavy-fermion compounds such as uranium or other transuranic compounds is carried out and accordingly anomalous magnetism and novel superconductivity phenomena are observed with these materials. In order to quantitatively clarify the electron structures of these magnetic compounds, we have developed a relativistic band theory based on the spin-density functional method. The goal of our research is to elucidate the Fermi surfaces and magnetic properties from the electron structures by the first principles calculation and to build a model that can systematically explain a variety of the measured results.

[Notable Publications and Works in the Last Three Years]
In colloidal crystals, the crystal structure and its lattice constant can be intentionally controlled by adjusting the size and surface charge of colloidal particles, salt concentration in the solution, and the volume fraction of colloidal particles. In colloidal crystals, the behavior of the constituent individual colloidal particles can be directly observed with an optical microscope. Therefore, it is possible to investigate in real time, for crystals in a variety of crystal systems, the lattice vibrations and phase transformations of constituent particles, planar defects and interfacial features, and the local structure and dynamic structural changes around defects. As a result, these crystals are good models for researching interesting problems in solid state physics.

In order to develop materials with new functions, our research group is using laser diffraction, particularly the Kossel diffraction technique, to study order formation processes and methods of controlling those processes in colloidal crystals. Research topics include (1) order formation and phase transformations in colloidal crystals, (2) creation of colloidal alloy crystals and determination of crystal structure, (3) creation of SiO₂ and TiO₂ colloidal crystals in zero gravity, (4) creation of quasicrystals in colloidal alloy crystals, and (5) changes in plane of polarization under diffraction conditions.

[Notable Publications and Works in the Last Three Years]


2. 愿山 毅, 曽我見 郁夫, 谷川 正幸, 篠原 忠臣 “コロイド合金結晶の構造解析と秩序形成過程” 京都産業大学 総合学術研究所所報 第5号 平成19年7月 p85-p98.

Division of Science (Physics)
Instructor  Atsunori Yonehara

- Area and Subject Taught: Observational Cosmology
- Research Theme(s):
  - Research on Astronomical Applications of Gravitational Lensing
- Academic Degrees: Doctor of Science, Kyoto University
- Keywords for Research Field:
  - Gravitational Lensing, Quasars, Extrasolar Planets, Interstellar Dust
- Office Phone Number: 81-75-705-1623

[Research Overview]
There are many types of objects in universe, and many types of phenomena are still occurring. At present, both theoretical and observational research are being carried out in order to clarify the true nature of objects, and the physics behind various phenomena. However, since the target objects are extremely distant, research is very different from experiments in a laboratory. It is always the problem that we can obtain only a limited amount of date from the target objects. To make bad things worse, electromagnetic radiation from the target objects is very faint.
Consequently, I am conducting research to develop more efficient observational approaches and data analysis techniques based on gravitational lensing, where the path of light is bent by the gravity of objects. If it is necessary for my research, I take any approach regardless of theoretical approach or observational approach. The gravitational lensing is a special phenomenon, and we can observe it only in huge spatial scale like universe. However, it is well known as a vital observational tool for astronomy today. At present, my specific research topics are exploring the environment and structure of quasars, and detection of extrasolar planets.

[Notable Publications and Works in the Last Three Years]