4. Research Reports

4.1. GCOE Program Members

The GCOE has been organized by the program members of 29 professors of Tohoku University. Their research fields are in Physics, Astronomy, Mathematics and Philosophy. The list of members and their research titles is as follows. Then, their research reports are the following.

- **Kunio Inoue** (Physics, Professor, Program Leader
  Search for neutrino-less double beta decay,
  Observation of geologically produced neutrinos,
  Precise measurement of neutrino oscillation parameters,

- **Ken-ichi Hikasa** (Physics, Professor)
  Theoretical High Energy Physics

- **Osamu Hashimoto** (Physics, Professor)
  Strangeness nuclear physics

- **Yoshio Kuramoto** (Physics, Professor)
  Theory of strongly correlated electrons and topological insulators

- **Yoshiro Hirayama** (Physics, Professor)
  Transport characteristics of semiconductor quantum systems,
  Hyperfine interactions and novel NMR (NER),
  NMR (NER) studies of semiconductor quantum systems,
  Nanoprobing of semiconductor quantum systems,
  Transport characteristics of nano-materials

- **Hirokazu Tamura** (Physics, Professor)
  Hypernuclear Physics

- **Masahiro Yamaguchi** (Physics, Professor)
  Beyond the Standard Model of Particle Physics

- **Riichiro Saito** (Physics, Professor)
  Optical properties of carbon nanotubes and graphene

- **Hitoshi Yamamoto** (Physics, Professor)
  Electron-positron colliders

- **Toshihiro Kawakatsu** (Physics, Professor)
  Study on structure and dynamics of soft matter

- **Teruya Ishihara** (Physics, Professor)
  Light-Matter interaction in metallic photonic crystals and metamaterials

- **Toshio Kobayashia** (Physics, Professor)
  Study on Unstable Nuclides

- **Hajime Shimizu** (Physics, Professor)
  Quark Nuclear Physics with a Photon Beam

- **Yasuhiro Sakemi** (Physics, Professor)
  Study of the violation of time reversal invariance with the search for electron electric dipole moment.

- **Kazuyoshi Yamada** (Physics, Professor)
  Neutron scattering studies on Cuprate Superconductors

- **Takashi Takahashi** (Physics, Professor)
  Ultrahigh-resolution photoemission study of topological insulators and novel superconductors

- **Katsumi Tanigaki** (Physics, Professor)
  Materials with regulated nano spaces: light-element strategy
  Carbon materials,
  Dirac-cone quantum states on topological consideration
  Molecular semiconductors: Fundamentals in device physics

- **Hideo Kozono** (Mathematics, Professor)
  Nonlinear Analysis

- **Motoko Kotani** (Mathematics, Professor)
  Mathematical challenge to a new phase of materials science

- **Reiko Miyaoka** (Mathematics, Professor)
  Hypersurface geometry and symplectic geometry

- **Takashi Shioya** (Mathematics, Professor)
  Geometry

- **Takyoshi Ogawa** (Mathematics, Professor)
  Real and Harmonic Analysis on Nonlinear PDE

- **Kazuhihiro Ishige** (Mathematics, Professor)
  Asymptotic profiles of the solutions for nonlinear parabolic equations

- **Toshifumi Futamase** (Astronomy, Professor)
  General Relativity, Cosmology

- **Takashi Ichikawa** (Astronomy, Professor)
  Study of galaxy evolution at high redshift universe and new instruments for infrared astronomy in Antarctica

- **Toru Yamada** (Astronomy, Professor)
  Galaxy Formation and Evolution

- **Makoto Hattori** (Astronomy, Professor)
  Construction of high accuracy components separation scheme for dramatic improvement of detection limit of primordial gravity wave origin cosmic microwave background polarization B-mode signal

- **Keiichi Noe** (Philosophy, Professor)
  Science and Technology after the Great East-Japan Earthquake
  Narratology of Historiography

- **Kiyotaka Naoe** (Philosophy, Associate Professor)
  Study of Philosophy and Ethics of Technology

Name	**Kunio Inoue**
Department	**Research Center for Neutrino Science**
Position	**Professor**
Research Title	**1. Search for neutrinoless double beta decay,** **2. Observation of geologically produced neutrinos,** **3. Precise measurement of neutrino oscillation parameters**

I. Summary of Research

1. We made a 3-m-diameter 25-μm-thickness Nylon mini-balloon in a class 1 super-clean-room. This mini-balloon was successfully deployed and inflated with dummy liquid-scintillator in KamLAND in the summer and the dummy scintillator was replaced by xenon-loaded-liquid-scintillator in the fall. The mini-balloon holds 330kg of dissolved xenon isotopically enriched in ^{136}Xe by 91%, containing the world largest amount of double beta decay nuclei. Thanks to the operating KamLAND detector, measurement has been smoothly started up and the first result was also provided very quickly. From an exposure of 77.6 days with 129 kg of ^{136}Xe in the fiducial volume, we've obtained the two-neutrino double-beta decay half-life as $T_{1/2}^{2\nu} = 2.38 \pm 0.02(\text{stat}) \pm 0.14(\text{syst}) \times 10^{21}$ years. It is the world highest statistics measurement and gives the resolution of the factor 5 contradiction argued in the past experiments. It also provided the lower limit of the neutrino-less double-beta decay half-life, $T_{1/2}^{0\nu} > 5.7 \times 10^{24}$ years at 90% confidence level, improving the previous limit by more than factor 5. This lower limit can be translated to the upper-limit of the effective Majorana neutrino mass by employing theoretical estimations of the nuclear matrix element. The obtained mass limit, $\langle m_{\beta\beta} \rangle < (0.3-0.6)$ eV, is already the world best sensitivity. The sensitivity is limited by the radioactive contamination in the xenon-loaded-liquid-scintillator. It might have come from xenon spallation by cosmic-rays when materials were aboveground or dust contamination of Fukushima-I fallout. Purification of xenon gas and liquid scintillator is being prepared now.
2. The xenon loaded mini-balloon occupies only 1.5% of the KamLAND sensitive region and it is expected that the mini-balloon doesn't disturb anti-neutrino detection. After the serious accident of Fukushima-I nuclear reactor, almost all nuclear reactors in Japan have been suspended. Given the situation of very little reactor operation, geo-neutrino figures very much in anti-neutrino signals. From the statistical point of view, current one-month data corresponds to about a half to one year data accumulation in the past. Data acquisition is smoothly running.
3. Low reactor neutrino flux is also important to verify our understanding to backgrounds.

Qualitatively, we've confirmed anti-neutrino signal rate really reduces.

II. Publications

1. "Measurement of the ^{8}B solar neutrino flux with the KamLAND liquid scintillator detector", KamLAND collaboration (S.Abe et al.), Phys.Rev.C84, 035804(2011).
2. "Partial radiogenic heat model for Earth revealed by geoneutrino measurements", KamLAND collaboration (A.Gando et al.), nature geoscience 4:647-651, 2011
3. "Search for extraterrestrial antineutrino sources with the KamLAND detector", KamLAND collaboration (A.Gando et al.), Astrophys.J., 745: 193, 2012.
4. "Measurement of the Double-Beta Decay Half-life of ^{136}Xe with the KamLAND-Zen experiment", KamLAND-Zen collaboration (A.Gando et al.), arXiv:1201.4664, to appear in PRC.

III. Presentations

1. "0v2β in KamLAND-Zen and SNO+", K. Inoue, Baryon and Lepton number Violation 2011, September 22-24, 2011, Gatlinburg, Tennessee.
2. "Can matter-particle and antimatter-particle be the same?", K. Inoue. GCOE symposium Weaving science web beyond particle matter hierarchy, February 20-22, 2012, Sendai.
3. "Prospects for data operation and system in the field of elementary particle physics", K. Inoue, High performance computing solution Amagi seminar, December 1-2, 2011, Ito. (in Japanese)
4. "Challenge to mysteries in particle physics and cosmology at the deep underground", K. Inoue, Tohoku University festival, November 5, 2011, Sendai, Japan. (in Japanese)
5. "Prospects for underground particle physics experiments", K. Inoue, Prospects for future high energy physics, 10 years from now, September 17, 2011, Hirosaki, Japan. (in Japanese)
6. "Astrophysics and particle physics at the ultra-low radioactive environment using a neutrino detector", K. Inoue, CRC town meeting, July 30, 2011, Kashiwa, Japan. (in Japanese)
7. "Future prospects of 0v2β study", K. Inoue, Town meeting for the future plan of high energy physics, July 29, 2011, IPMU, Kashiwa, Japan. (in Japanese)
8. "Key in a tiny particle, neutrino, for solving the questions of huge universe", K. Inoue, Yume-navi live, July 12, 2011, intex Osaka, Osaka, Japan. (in Japanese)
9. "Prospects for underground particle physics experiments", K. Inoue, Town meeting for the future plan of high energy physics, June 25, 2011, Koshiba hall, Tokyo, Japan. (in Japanese)
10. "Search for neutrino-less double beta decay", K. Inoue, Wednesday lunch talk, June 1, 2011, Sendai, Japan. (in Japanese)

IV. Prizes (Awards)

1. Honor of the distinguished professor in Tohoku University.

Hiroko Watanabe (Neutrino Physics, D3), Award of the President of Tohoku University for the doctoral thesis of “Comprehensive study of Anti-neutrino Signals at LamLAND” (March 27, 2012).

Hiroko Watanabe (Neutrino Physics, D3), Chika Kuroda Prize (Awarded by AOBA-Science, Graduate School of Science, Tohoku University) for the study on the neutrino physics, “Comprehensive study of Anti-neutrino Signals at LamLAND”, (March 19, 2012).

Name **Ken-ichi Hikasa**
Department **Physics**
Position **Professor**
Research Title **Theoretical High Energy Physics**

I. Summary of Research

1. For the search of neutralino dark matter, the knowledge of its allowed mass and scattering cross section with the nucleon is important. We scan over the parameter space of the next-to-minimal supersymmetric standard model, assuming all the relevant soft mass parameters to be below TeV scale. We find that the neutralino dark matter can be as light as a few GeV and its scattering rate off the nucleon can reach the sensitivity of XENON100 and CoGeNT. A sizable parameter space is thus excluded by the current data. Moreover, in such a light dark matter scenario a light Higgs boson must be present to satisfy the measured dark matter relic density. Consequently, the SM-like Higgs boson h may decay predominantly into a pair of light Higgs bosons or a pair of neutralinos so that the conventional decays like $h \to \gamma\gamma$ is much suppressed.
2. As a top quark factory, the LHC can test the new physics models used to explain the top quark forward-backward asymmetry A_{FB}^{t} measured at the Tevatron. We perform a comparative study for two such models: the W' model and the color triplet diquark (φ) model. Requiring these models also satisfy the top pair production rate measured at the Tevatron, we examine their contributions to the LHC observables such as the polarization and charge asymmetry in top quark and W' (or φ) productions. We find that these observables can be enhanced to the observable level and the current LHC measurement on the top charge asymmetry can already tightly constrain the W' model. We also find that each observable shows different characteristics in different models, which can be utilized to discriminate the models.

II. Publications

1. “Light dark matter in NMSSM and implication on Higgs phenomenology”
   J. Cao, K. Hikasa, W. Wang, and J. M. Yang
   Physics Letters B **703**, 292-297 (September, 2011).
2. “Testing new physics models by top charge asymmetry and polarization at the LHC”
   J. Cao, K. Hikasa, W. Wang, L. Wu, and J. M. Yang
   Physical Review D **85**, 014025 (January, 2012)

IV. Prizes (Awards)

Ryuichiro Kitano (Particle Physics, Associate Prof.), Particle Physics Medal: Young Scientist Award in Theoretical Particle Physics, for the study on “Sweet spot Supersymmetry”, Journal of High Energy Physics 0708 (2007) 016 (March 26, 2012).

Fuminobu Takahashi (Particle Physics, Associate Prof.), Young Scientist Award of the Physical Society of Japan for the study on “Gravitino overproduction in inflaton decay”; Phys. Lett.B 638(2006) 8, “The gravitino overproduction problem in inflationary universe”; Phys. Rev. D74(2006)043519, and “Inflaton Decay in Supergravity”; Phys. Rev D76(2007)083509 (September 17, 2011).

Name **Yoshio Kuramoto**
Department **Physics**
Position **Professor**
Research Title **Theory of strongly correlated electrons and topological insulators**

I. Summary of Research

1. Generalized Kondo lattice models with non-Kramers f-electron configuration are studied by means of highly accurate continuous-time quantum Monte Carlo method. We have shown that a composite order parameter arises in the two-channel Kondo lattice, which can be interpreted as itinerant octupole order.
2. The Kondo problem with simultaneous presence of strong potential scattering is studied by combining the continuous-time quantum Monte Carlo method and analytic theory. We have shown that the density of states acquires strong asymmetry by the potential scattering, which gives rise to non-monotonous temperature dependence of the electrical resistivity.
3. Surface excitation modes in topological insulators (TI) are derived for the tight-binding model that simulates the actual TI Bi2Se3. We have clarified the spectrum of the helical mode over the whole Brillouin zone. It is shown that helical surface modes appear even for topologically trivial cases, but that their energy is overlapping with bulk excitations.

II. Publications

1. “Spin Density Wave Driven by Quadrupolar Kondo Effect in Two-Channel Kondo Lattice”
   Shintaro Hoshino, Junya Otsuki, and Yoshio Kuramoto:
   J. Phys. Soc. Jpn. 80 (2011) SA135-1 -- SA135-3
2. “Electronic Orders Induced by Kondo Effect in Non-Kramers f-Electron Systems”
   Yoshio Kuramoto, Shintaro Hoshino, and Junya Otsuki:
   J. Phys. Soc. Jpn. 80 (2011) SA018-1 -- SA018-6
3. “Disorder-Induced Multiple Transition Involving Z2 Topological Insulator”
   Ai Yamakage, Kentaro Nomura, Ken-Ichiro Imura, and Yoshio Kuramoto:
   J. Phys. Soc. Jpn. 80 (2011) 053703-1 --053703-5
4. “Microscopic Mechanism for Staggered Scalar Order in PrFe4P12”
   Shintaro Hoshino, Junya Otsuki, and Yoshio Kuramoto:
   J. Phys. Soc. Jpn. 80 (2011) 033703-1 -- 033703-4
5. “Flat edge modes of graphene and of Z 2 topological insulator”
   Ken-Ichiro Imura, Shijun Mao, Ai Yamakage and Yoshio Kuramoto
   Nanoscale Research Letters 6 (2011) 358-1 - 358-6 (April)

6. “Tight-binding model for topological insulators: Analysis of helical surface modes over the whole Brillouin zone”
   Shijun Mao, Ai Yamakage, and Yoshio Kuramoto:
   Phys. Rev. B 84, 115413-1 -- 115413-14 (2011)
7. “Numerical study of Kondo impurity models with strong potential scattering: Reverse Kondo effect and antiresonance”
   A. Kiss, Y. Kuramoto, and S. Hoshino:
   Phys. Rev. B 84, 174402 (2011)
8. “Diagonal Composite Order in a Two-Channel Kondo Lattice”
   Shintaro Hoshino, Junya Otsuki, and Yoshio Kuramoto:
   Phys. Rev. Letters 107, 247202 (2011)

III. Presentations

1. “Theory for fullerene superconductivity by repulsive interaction model”
   S. Yamazaki and Y. Kuramoto: Divisional Meeting of the Physical Society of Japan, 21-24 September 2011, Toyama, Japan
2. “Summary -- Outlook for Investigation of Multipoles”
   Y. Kuramoto: Divisional Meeting of the Physical Society of Japan, 21-24 September 2011, Toyama, Japan
3. “Octupole Order Induced by Strong Interaction between Non-Kramers Doublets and C onduction Electrons”
   S. Hoshino, J. Otsuki and Y. Kuramoto: Divisional Meeting of the Physical Society o f Japan, 21-24 September 2011, Toyama, Japan
4. “Interference effects of helical current”
   S. Masuda and Y. Kuramoto: Divisional Meeting of the Physical Society of Japan, 21-24 September 2011, Toyama, Japan
5. “Magnetic Order with Odd-Frequency Order Parameter”
   Y. Kuramoto: Annual Meeting of the Physical Society of Japan, 24-27 March 2012, Kwansei-Gakuin, Japan
6. “Induced magnetic order in Kondo lattice by dilution of f electrons”
   S. Hoshino and Y. Kuramoto: Annual Meeting of the Physical Society of Japan, 24-27 March 2012, Kwansei-Gakuin, Japan

IV. Prizes (Awards)

Shintaro Hoshino (Condensed Matter Physics, D3), Physics Department Prize for the doctoral thesis, Graduate School of Science, Tohoku University, (February 24, 2012).

Hisatoshi Yokoyama (Condensed Matter Physics, Assistant Prof.), Award of Editor's Choice for the paper of "Effect of Doublon-Holon Binding on Mott transition---Variational Monte Carlo Study of Two-Dimensional Bose Hubbard Models", Journal of the Physical Society of Japan (JPSJ), (August 10, 2011).

Sumio Ishihara (Condensed Matter Physics, Associate Prof.), Award of Editors' Suggestion for the paper of "Polarization-analyzed resonant inelastic x-ray scattering of the orbital excitations in KCuF3", Physical Review B; Rapid Communications, (June 14, 2011).

Name	**Yoshiro Hirayama**
Department	**Department of Physics, Graduate School of Science**
Position	**Professor**
Research Titles	**1. Transport characteristics of semiconductor quantum systems,** **2. Hyperfine interactions and novel NMR (NER),** **3. NMR (NER) studies of semiconductor quantum systems,** **4. Nanoprobing of semiconductor quantum systems,** **5. Transport characteristics of nano-materials**

I. Summary of Research

1. We have demonstrated highly-sensitive resistively-detected (RD)-NMR (Nuclear Magnetic Resonance) in InSb quantum wells. By using Landau-level (LL) crossings in a tilted magnetic field and domain formation at the n=2 LL crossing point, we have succeeded to show dynamic nuclear polarization by current flow and its resistive detection. This newly developed NMR was extended to high temperature regime. The resistively-detected NMR signal of ^{115}In can be detected up to 4 K, although the signal amplitude decreases with temperature. We suggest that this upper limit temperature corresponds to the Curie temperature of the Ising quantum Hall ferromagtneto at n=2 LL crossing. Along this study, the spin polarization (P) of high-density InSb two-dimensional electron systems (2DESs) has been measured using both parallel and tilted magnetic fields. The obtained P exhibits a superlinear increase with the total field B. This behavior can be explained by assuming linear P -g* relation. A significant change of g* from 39 at P = 0 to 88 at P = 1 was obtained in our InSb 2DES.

2. A method is proposed for obtaining the spectrum for noise that causes the phase decoherence of a spin (qubit) system directly from experimentally available data. The method is based on a simple relationship between the spectrum and the coherence time of the spin (qubit) in the presence of a pulse sequence. The relationship is found to hold for every system of a spin (qubit) interacting with the classical-noise, bosonic, and spin baths. This proposal provides us very useful method to evaluate the noise spectrum of spin, nuclear spin, and many types of qubits.

3. We have studied electron spin features of GaAs/AlGaAs hetero- and nano-structures by using highly-sensitive RD-NMR. Recently, we extended such nuclear relaxation measurement to quasi-one-dimensional wires. We have developed a technique to measure the local nuclear spin relaxation in the wire with a typical width and length of 500 nm and 3 μm, respectively. We found a suppression of nuclear relaxation in the wire confinement. The wire width is larger than

the individual Skyrmion size so that this feature suggests modification of the multi-Skyrmion state. We speculate that the Skyrmion crystal is melted into the Skyrmion liquid as the wire becomes narrower.

4. Nuclear spins in a single quantum well are polarized by optical pumping and its polarization is detected by a shift of the resistance peak of the SPT (spin-phase-transition) at Landau level filling factor $\nu = 2/3$. The SPT peak shift changes its sign depending on the polarization direction of the optical pumping. Application of resonant-frequency rf magnetic-field induces the peak shift, confirming optically pumped nuclear polarization. The optical nuclear polarization has a wide controllability and its combination with highly-sensitive resistance detection will open a new way for nuclear spin manipulation in semiconductors.

5. The metal-insulator transition is very important in two-dimensional systems. In certain Si quantum well, it is possible to control valley splitting. This novel valley splitting opens us a new study of metal-insulator transition where both valley and spin degrees of freedom play an essential role.

6. The mechanical system is important to study coupling between mechanical motion and transport characteristics. We theoretically clarify a vibration mode of a rolled semiconductor.

7. We are collaborating with many outside organizations. We work together with researchers from ERATO Nuclear Spin Electronics Project (ERATO-NSEP). In this frame, we are collaborating with NTT, Oklahoma Univ., Univ. of Tokyo, and Niigata Univ. We are also collaborating with Paul-Drude-Institute (PDI) (Germany), Bath University (England), University of New South Wales (Australia), Tsukuba University and Chiba University. Especially, we would like to thank NTT, PDI, and Oklahoma University for providing us high quality heterostructures.

II. Publications

1. “Resistively detected nuclear magnetic resonance via a single InSb two-dimensional electron gas at high temperature”,
   K. F. Yang, H. W. Liu, K. Nagase, T. D. Mishima, M. B. Santos, and Y. Hirayama,
   Appl. Phys. Lett. 98, 142109 (2011).
2. “Impact of Valley Polarization on the Resistivity in Two Dimension”,
   K.Takashina, Y. Niida, V. T. Renard, A. Fujiwara, T. Fujisawa, K. Muraki, and Y. Hirayama,
   Phys. Rev. Lett. 106, 196403 (2011).

3. “Nonlinear magnetic field dependence of spin polarization in high density two-dimensional electron systems”,
   K. F. Yang, H. W. Liu, T. D. Mishima, M. B. Santos, K. Nagase, and Y. Hirayama,
   New Journal of Physics 13, 083010 (2011).
4. “Resistive detection of optical nuclear polarization with spin phase transition peak at Landau level filling factor 2/3”,
   K. Akiba, S. Kanasugi, K. Nagase, and Y. Hirayama,
   Appl. Phys. Lett., 99, 112106 (2011).
5. “Low-frequency spin fluctuations in skyrmions confined by wires: Measurements of local nuclear spin relaxation”,
   Takashi Kobayashi, Norio Kumada, Takeshi Ota, Satoshi Sasaki, and Yoshiro Hirayama,
   Phys. Rev. Lett. 107, 126807 (2011).
6. “Measurement of noise spectrum using a multiple-pulse sequence”,
   Tatsuro Yuge, Susumu Sasaki, and Yoshiro Hirayama,
   Phys. Rev. Lett. 107, 170504 (2011).
7. “Motion detection of a micromechanical cantilever through magneto-piezovoltage in two-dimensional electron systems”,
   H. Yamaguchi, H. Okamoto, S. Ishihara, and Y. Hirayama,
   Appl. Phys. Lett. 100, 012106 (2012).
8. “Mechanical vibration of a cylindrically rolled-up cantilever shell in microelectromechanical and nanoelectromechanical systems”,
   W. Izumida, Y. Hirayama, H. Okamoto, H. Yamaguchi, and K. –J. Friedland,
   Phys. Rev. B85, 075313 (2012).

III. Presentations

1. “Electrical transport properties in single-walled carbon nanotubes networks”,
   K. Snoussi, A. Vakhshouri, H. Okimoto, T. Takenobu, Y. Iwasa, S. Maruyama, K. Hashimoto, and Y. Hirayama, The 38th Int. Conf. on Compound Semiconductors (ISCS2011) (Berlin, May 22-26, 2011).
2. “Dynamic nuclear polarization in a single InSb 2DEG at elevated temperatures”,
   H. W. Liu, K. Yang, K. Nagase, T. D. Mishima, M. B. Santos, and Y. Hirayama, The 38th Int. Conf. on Compound Semiconductors (ISCS2011) (Berlin, May 22-26, 2011).
3. “Resistively-detected nuclear-magnetic-resonance in InSb two-dimensional electron systems”,
   Yoshiro Hirayama and Hongwu Liu, Japan-Sweden QNANO Workshop (QNANO2011)

(Visby, Sweden, June 12-14, 2011) (invited).

4. “All Electrical Probe of Nuclear Spin Polarization and Relaxation by Spin Phase Transition Peaks of the Filling Factor nu=2/3 Quantum Hall Effect”,
   M. H. Fauzi, S. Watanabe, N. Kumada, and Y. Hirayama, The15th Int. Symp. on the Physics of Semiconductors and Applications (ISPSA-XV) (Jeju, Korea, July 5-8, 2011)
5. “Optical nuclear polarization and its resistive detection by spin phase transition peak in nu=2/3 quantum Hall regime”,
   K. Akiba, S. Kanasugi, K. Nagase, and Y. Hirayama, The 19th Int. Conf. on Electronic Properties of Two-Dimensional System (EP2DS19) (Tallahassee, Florida, July 25-29, 2011).
6. “Measurement of nuclear spin diffusion in double quantum wells”,
   T. Hatano, W. Kume, K. Akiba, S. Watanabe, K. Nagase, and Y. Hirayama, The 19th Int. Conf. on Electronic Properties of Two-Dimensional System (EP2DS19) (Tallahassee, Florida, July 25-29, 2011).
7. “Filling-factor dependence of nuclear spin polarization in quantum Hall regime”,
   S. Watanabe, N. Kumada, and Y. Hirayama, The 19th Int. Conf. on Electronic Properties of Two-Dimensional System (EP2DS19) (Tallahassee, Florida, July 25-29, 2011).
8. “Subband energy manipulation by gate voltages in a Si (100) hole system”,
   Y. Niida, K. Takashina, A. Fujiwara, Y. Ono, and Y. Hirayama, The 19th Int. Conf. on the Application The 19th Int. Conf. on Electronic Properties of Two-Dimensional System (EP2DS19) (Tallahassee, Florida, July 25-29, 2011).
9. “Quantized cyclotron orbits observed by Fourier transform scanning tunneling microscopy”,
   K. Hashimoto, T. Champel, C. Sohrmann, J. Wiebe, Y. Hirayama, R. A. Roemer, S. Florens, R. Wiesendanger, and M. Morgenstern, Int. Workshop on Quantum Nanostructures and Nanoelectronics (QNN2011) (Tokyo, October 3-4, 2011).
10. “Gate Controlled InSb Two-Dimensional Electron Gas and its Perspectives”,
    M. M. Uddin, H. W. Liu, K. F. Yang, T. D. Mishima, M. B. Santos, K. Nagase, and Y. Hirayama, Int. Workshop on Quantum Nanostructures and Nanoelectronics (QNN2011) (Tokyo, October 3-4, 2011).
11. “Spectrum of Dephasing Noise on a Qubit - Theory and Experiment”,
    S. Sasaki, T. Yuge, M. Nishimori, T. Kawanago, H. Tanaka, Y. Hirayama, International Symposium on Advanced Nanodevices and Nanotechnology (ISANN 2011) (Kaanapali,Hawaii, December 4 - 9, 2011).

Name **Hirokazu Tamura**
Department **Physics**
Position **Professor**
Research Title **Hypernuclear Physics**

I. Summary of Research

1. As the first experiment using the SKS spectrometer system which we constructed at the K1.8 beam line in the J-PARC hadron hall, we searched for a pentaquark Θ^+ particle by the $p(\pi^-,K^-)\Theta^+$ reaction. No peak was found in the missing mass spectrum around the previously reported mass and we set a stringent limit of the production cross section in this reaction.
2. In order to carry out hypernuclear γ-ray spectroscopy experiments at J-PARC, we have been constructing a new Ge detector array, Hyperball-J. We successfully finished R&D works for a new type of low-temperature mechanically-cooled Ge detectors and fast background suppression counters using PWO scintillator. After the R&D, these detectors have been manufactured, assembled and tested.
3. For the first γ-ray spectroscopy experiment (E13), we carried out a detailed computer simulation. Based on the simulation result, we decided to take data on $^{4}_{\Lambda}$He for one week and $^{19}_{\Lambda}$F for 3 weeks with 10kW beam power, and to take other data when the beam power is much increased.

II. Publications

1. “Gamma spectroscopy of hypernuclei: a decade of Hyperball project and future plans at J-PARC”, H. Tamura, Y. Ma, N. Chiga, K. Hosomi, T. Koike, M. Mimori, K. Miwa, M. Sato, K. Shirotori, M. Ukai, and T. O. Yamamoto, Nucl. Phys. A 835, 3-10 (2010).
2. “Updated results on the $^{11}_{\Lambda}$B and $^{12}_{\Lambda}$C γ-ray spectroscopy study”, Y. Ma, S. Ajimura, K. Aoki, M. Dairaku, Y.Y. Fu, H. Fujioka, T. Fukuda, K. Futatsukawa, K. Hosomi, W. Iwamoto, M. Kawai, Y. Kakiguchi, S. Kinoshita, T. Koike, N. Maruyama. M. Mimori, S. Minami, Y. Miura, K. Miwa, Y. Miyagi, T. Nagae, D. Nakajima, H. Noumi, K. Shirotori, T. Suzuki, T. Takahashi, T.N. Takahashi, H. Tamura, K. Tanida, N. Terada, A. Toyoda, K. Tsukada, M. Ukai, S.H. Zhou, Nucl. Phys. A 835, 422-425 (2010).
3. “Coincidence measurement of the weak decay of $^{12}_{\Lambda}$C and the three-body weak decay process”, M. Kim, S. Ajimura, K. Aoki, A. Banu, H. Bhang, T. Fukuda, O. Hashimoto, J. I. Hwang, S. Kameoka, B. H. Kang, E. H. Kim, J. H. Kim, T. Maruta, Y. Miura, Y. Miyake, T. Nagae, M. Nakamura, S. N. Nakamura, H. Noumi, S. Okada, Y. Okayasu, H. Outa, H. Park, P. K. Saha, Y. Sato, M. Sekimoto, S. Shin, T. Takahashi, H. Tamura, K. Tanida, A. Toyota, K.

Tsukada, T. Watanabe and H. J. Yim, Nucl. Phys. A 835, 434-438 (2010).

4. "Λ hypernuclei via gamma-ray spectroscopy",
   H. Tamura, Prog. Theor. Phys. Suppl. 185, 315-334 (2010).
5. "Active target system with MPPC readout for hyperon-proton scattering experiment"
   K. Miwa, R. Honda, K. Hosomi, T. Koike, Y. Ma, T. Otani, M. Sato, K. Shirotori, H. Tamura, T. Yamamoto, Y. Yonemoto", PoS PD09, 027 (2010).
6. "Recent Progress in the Study of Nonmesonic Weak Decay of Λ Hypernuclei",
   H. Bhang, S. Ajimura, K. Aoki, A. Banu, T. Fukuda, O. Hashimoto, J. I. Hwang, S. Kameoka, B. H. Kang, E. Kim, J. H. Kim, M. Kim, T. Maruta, Y. Miura, Y. Miyake, T. Nagae, M. Nakamura, S. N. Nakamura, H. Noumi, S. Okada, Y. Okayasu, H. Outa, H. Park, P. K. Saha, Y. Sato, M. Sekimoto, S. Shin, T. Takahashi, H. Tamura, K. Tanida, A. Toyota, K. Tsukata, T. Watanabe and H. J. Yim, Int. J. Mod. Phys. E19, 2558-2565 (2010)
7. "Hypernuclear Spectroscopy with Heavy Ion Beams: The HypHI Project at GSI and FAIR",
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8. "Chirality in the Mass 80 Region: ^{79}Kr",
   Koike T, Kinoshita S, Ma Y, Miura Y, Shirotori K, Tamura H, Ukai M, Suzuki T, Endo T, Fujita M, Miyashita Y, Ohguma M, Sato N, Shinozuka T, Tateoka M, Wakui T, Yamazaki A, Fukuchi T, Timar J, Joshi P, Ahn T, Rainovski G, Fu YY,
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9. "The first experiment at the J-PARC K1.8 beam line using the SKS spectrometer",
   K. Shirotori for the K1.8 collaboration, J. Phys. Conf. Ser. 312 052023 (2011).
10. "The three-body nonmesonic weak decay process of $^{12}_{\Lambda}$C hypernucleus and its exclusive measurement at J-PARC (E18)", H. Bhang et al., J. Phys. Conf. Ser. 312, 022009 (2011).
11. "Spectroscopic investigation of Λ hypernuclei in the wide mass region using the (e, e'K$^+$) reaction", S. N. Nakamura et al., J. Phys. Conf. Ser. 312, 092047 (2011)
12. "Binding energy of $^{7}_{\Lambda}$He and test of charge symmetry breaking in the ΛN interaction potential", O. Hashimoto et al., J. Phys. Conf. Ser. 312, 022015 (2011).
13. "World of hypernuclei revealed by precision γ-ray spectroscopy",
   M. Ukai and H. Tamura, BUTSURI 67, 14 -23, (2012).
14. "Study of Λ hypernuclei using hadron beams and γ-ray spectroscopy at J-PARC",

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III. Presentations

1. “J-PARC and beyond”, H. Tamura, Joint SPHERE and JSPS Core-to-Core Seminar, Sept. 4-6, 2010, Prague, Czech (invited talk).
2. “Spectroscopy of hypernuclei --experiment”, H. Tamura, 22nd Indian Summer School on Strangeness Nuclear Physics, Sept.7-11, 2010, Prague, Czech (invited lecture).
3. ”Nuclear Physics at J-PARC", H. Tamura, Int. Symp. on Nuclear Physics in Asia, October 14-15, 2010, Beijing, China (invited talk).
4. “Nuclear Physics at J-PARC”, H. Tamura, Int. Symp. on New Faces of Atomic Nuclei, November 15-17, 2010, Okinawa, Japan (invited talk).
5. “Nuclear matter in neutron stars studied by experiments and astronomical observations”, H. Tamura, Japan-Korea Meeting on Nuclear and Particle Physics at J-PARC Hadron Hall, November 29-30, 2010, Seoul, Korea (invited talk).
6. “Gamma-ray spectroscopy of hypernuclei”, H. Tamura, RIBF ULIC and CNS Symposium on Frontier of gamma-ray spectroscopy (gamma11), June 30-July 2, 2011, RIKEN, Wako, Japan (invited talk).
7. “Hyperons in nuclei – review”, H. Tamura, XIV International Conference on Hadron Spectroscopy (Hadron2011), June 13-17, 2011, Munich, Germany (invited talk).
8. “Production of hypernculei by hadronic probes (S=-1 hypernuclei)”, H. Tamura, ECT* workshop on Strange Hadronic Matter, September 26-30, 2011, Trento, Italy (invited talk).
9. “Hypernuclear physics via γ-ray spectroscopy”, H. Tamura, 2011 Fall Meeting of the APS Division of Nuclear Physics, October 26-29, Michigan State University, East Lansing, Michigan, USA (invited talk).
10. “Structure of Hypernuclei and ΛN Tensor Force”, H. Tamura, Int. Symp. on Frontiers in Nuclear Physics --Tensor Interaction in Nuclear and Hadron Physics— , November 2-3, 2011, Beihang University, Beijing, China.

IV. Prizes (Awards)

Kouji Miwa (Nuclear Physics, Assistant Prof.), Young Scientist Award of the Physical Society of Japan for the study on “Search for Q^+ via $\pi^- p \rightarrow K^- X$ reaction near production threshold”; Phys. Lett. B 635 (2006) 72, and “Search for the Q^+ via the $K^+ p \rightarrow \pi^+ X$ reaction with a 1.2 GeV/c K^+ beam”; Phys. Rev. C 77, 045203 (2008), (March 26, 2012).

Name **Masahiro Yamaguchi**
Department **Physics**
Position **Professor**
Research Title **Beyond the Standard Model of Particle Physics**

I. Summary of Research

1. We study a Peccei-Quinn invariant extension of the next-to-minimal supersymmetric Standard Model (NMSSM), which turns out to be free from the tadpole and domain wall problems. Having a non-renormalizable coupling to the axion superfield, the SM singlet added to the Higgs sector can naturally generate an effective Higgs mu term around the weak scale. In the model, the lightest neutralino is dominated by the singlino, which gets a mass only through mixing with the neutral Higgsinos. We explore the phenomenological consequences resulting from the existence of such a relatively light neutralino. The coupling of the SM singlet to the Higgs doublets is constrained by the experimental bound on the invisible Z-boson decay width. Under this constraint, we examine the properties of the SM-like Higgs boson paying attention to its mass and decays. We also demonstrate a UV completion of the model in SU(5) grand unified theory with a missing-partner mechanism.
2. We consider, in the context of the minimal supersymmetric standard model, the case where the gravitino weighs 10^6 GeV or more, which is preferred by various cosmological difficulties associated with unstable gravitinos. The large Higgs mixing parameter B together with the little hierarchy to other soft supersymmetry breaking masses causes a serious mu/Bmu problem. We show that a light higgsino with an electroweak scale mass provides a simple solution to this problem, where the higgsino mixing mu parameter is tuned for the electroweak symmetry breaking to take place. Furthermore the light higgsinos produced at the decays of gravitinos can constitute the dark matter of the universe. The heavy squark mass spectrum of O(10^4) GeV can increase the Higgs boson mass to about 125 GeV or higher.
3. Models with anomalous U(1) gauge symmetry contain various superfields which can have nonzero supersymmetry breaking auxiliary components providing the origin of soft terms in the visible sector, e.g. the U(1) vector superfield, the modulus or dilaton superfield implementing the Green-Schwarz anomaly cancellation mechanism, U(1)-charged but standard model singlet matter superfield required to cancel the Fayet-Iliopoulos term, and finally the supergravity multiplet. We examine the relative strength between these supersymmetry breaking components in a simple class of models, and find that various different mixed mediations of supersymmetry breaking, involving the modulus, gauge,

anomaly and D-term mediations, can be realized depending upon the characteristics of D-flat directions and how those D-flat directions are stabilized with a vanishing cosmological constant. We identify two parameters which represent such properties and thus characterize how the various mediations are mixed. We also discuss the moduli stabilization and soft terms in a variant of KKLT scenario, in which the visible sector Kaehler modulus is stabilized by the D-term potential of anomalous U(1) gauge symmetry

II. Publications

1. “Peccei-Quinn invariant extension of the NMSSM”, K.S. Jeong, Y. Shoji, M. Yamaguchi, JHEP 1204, 022 (2012).
2. “Mixed Mediation of Supersymmetry Breaking with Anomalous U(1) Gauge Symmetry”, K. Choi, K.S. Jeong, K. Okumura, M. Yamaguchi, JHEP 1106, 049 (2011).
3. “Axion model in gauge-mediated supersymmetry breaking and a solution to the mu/Bmu problem”, K.S. Jeong, M. Yamaguchi, JHEP 1107.124 (2011).

III. Presentations

Name **Riichiro Saito**

Department **Physics**

Position **Professor**

Research Title **Optical properties of carbon nanotubes and graphene**

I. Summary of Research

1. We have published two books on nanotube and graphene in Japanese as co-editors.
2. Coherent phonon spectroscopy of carbon nanotubes has been investigated. We explain the reason why a carbon nanotube starts vibration by either expanding and shrinking the diameter.
3. Raman spectroscopy of bilayer and triple layer graphene is calculated especially for a special spectral energy region which is sensitive to the stacking order of triple layer graphene.

II. Publications

1. “Raman spectroscopy of graphene edges”, in “Graphene and its fascinating attributes”, R. Saito, Eds. S. K. Pati, T. Enoki, C. N. R. Rao, pp 91-103, World Scientific, Singapole, (2011).
2. “Double-walled carbon nanotubes: Synthesis, Characterization and Applications”, M. Endo, Y. A. Kim, T. Hayashi, H. Muramatsu, R. Saito, M. Terrones, M. S. Dresselhaus, Encyclopedia of Nanoscience and Nanotechnology, Ed. H. S. Nalwa, Vol. 13, pp. 113-158, American Scientific Publishers, Valencia, CA, USA, (2011).
3. “Photoluminescence of CNT”, in Japanese, R. Saito, Handbook of graphene and nanotubes, Ed. Y. Saito pp 167-172, Corona Pub. (2011).
4. “Chiral index (n,m) and electronic properties” in Japanese, R. Saito, Tansogaku, Eds. K. Tanaka, H. Tohara, H. Shinohara, pp.358-365, Kagaku-Doujin, (2011).
5. “Second-order Overtone and Combinational Raman Modes of Graphene Layers in the Range of 1690 cm^{-1} to 2150 cm^{-1}.”, C. Cong, Y. Ting, R. Saito, G. Dresselhaus, M. S. Dresselhaus, ACS Nano **5**, 1600-1605 (2011).
6. “Vibrational and NMR properties of polyynes”, Md. M. Haque, L. C. Yin, A. R. T. Nugraha, R. Saito, Carbon **49**, 3340-3345 (2011).
7. “D band Raman intensity calculation in armchair edged graphene nanoribbons”, E. B. Barros, K. Sato, Ge. G.Samsonidge, M. S. Dresselhaus, R. Saito, Phys. Rev. B **83**, 245435-1-8 (2011).
8. “Raman spectroscopy of Graphene and Carbon Nanotubes”, R. Saito, M. Hofman, G. Dresselhaus, A. Jorio, M. S. Dresselhaus, Advances in Physics **60**, 413-550 (2011).
9. “Raman spectra of out-of-plane phonons in bi-layer graphene”, K. Sato, J. S. Park, R. Saito, C. Cong, Y. Ting, C. Hung, T. F. Heinz, G. Dresselhaus, M. S. Dresselhaus, Phys. Rev. B **84**,

035419-1-5 (2011).

10. "Resonant Raman spectroscopy on enriched 13C carbon nanotubes", S. Costa, C. Fantini, A. Righi, A. Backmatiuk, R. Schohfelder, M. H. Ruemmeli, R. Saito, M. A. Pimenta, Carbon **49**, 4719-4723 (2011).
11. "Fermi level dependent optical transition energy in metallic single-walled carbon nanotubes", L. C. Yin, H. M. Cheng, R. Saito, M. S. Dresselhaus, Carbon **49**, 4774-4780 (2011).
12. "Tunneling time of optical pulse in photonic band gap", R. Endo, R. Saito, J. Opt. Soc. Am. B **28**, 2537-2542 (2011).
13. "Observation of electronic Raman scattering in metallic carbon nanotubes", H. Farhat, S. Berciaud, M. Kalbac, R. Saito, T. F. Heinz, M. S. Dresselhaus, J. Kong, Phys. Rev. Lett. **107**, 157401-1-4 (2011).
14. "First principles calculations of the electronic structure of hexagonal ZrN allotropes", L. C. Yin, R. Saito, J. Phys. Soc. Japan **80**, 114707-1-6 (2011).
15. "Polar interface-induced higher photocatalytic hydrogen evolution over ZnO-CdS heterostructures", X. Wang, L. C. Yin, G. Liu, L. Wang, R. Saito, G. Q. Lu, H. M. Cheng, Energy Env. Sci. **4**, 3976-3979 (2011).
16. "Chirality dependence of coherent phonon amplitudes in single wall carbon nanotubes", A. R. T. Nugraha, G. D. Sanders, K. Sato, C. J. Stanton, M. S. Dresselhaus, R. Saito, Phys. Rev. B **84**, 174302-1-6 (2011).
17. "Raman characterization of ABA and ABC stacked trilayer grapheme", C. Cong, T. Yu, K. Sato, J. Shang, R. Saito, G. Dresselhaus, M. S. Dresselhaus, ACS Nano **11**, 8760-8768 (2011).

III. Presentations

1. "Raman and coherent phonon spectroscopy of nanotube and edge of graphene (invited)", R. Saito, A.R.T. Nugraha, K. Sato, K. Sasaki, C. Conxiao, Y. Ting, G. Dresselhaus, M.S. Dresselhaus, 4th Workshop on Nanotube optics and nanospectroscopy (Wonton'11), University of Bordeaux, Talence, Fance, (2011.5.29-6.1).
2. "Chirality dependence of coherent phonon amplitudes in carbon nanotubes", A.R.T. Nugraha, R. Saito, Postgraduate, Workshop on Nanoscience and Nanotechnology 2011. Hong Kong University of Science and Technology, HongKong, (2011.6.15-17).
3. "Second-order overtone and combinational Raman modes of graphene layers in the Range of 1690cm^{-1} to 2150cm^{-1}", C. Cong, T. Yu, R. Saito, G. Dresselhaus, M.S. Dresselhaus, International Conference on Materials for Advanced Technologies (ICMAT 2011), Suntec, Singapore, (2011.6.26-7.1).
4. "Coherent phonon spectroscopy of single wall carbon nanotubes", R. Saito, A.R.T. Nugraha,

K. Sato, G.D. Sanders, C.J. Stanton, G. Dresselhaus, M.S. Dresselhaus, 12th International Conference on the Science and Application of Nanotubes (NT11), Cambridge, United Kingdom, (2011.7.10-14).

5. “Resonant Raman Spectroscopy on 13C Enriched Carbon Nanomaterials”, S. Costa, C. Fantini, A. Righi, A. Bachmatiuk, M.H. Rummeli, R. Saito, Y.F. Hao, C. Magnuson, R. Ruoff, M. A. Pimenta,12th International Conference on the Science and Application of Nanotubes (NT11), Cambridge, United Kingdom, (2011.7.10-14).
6. “Raman spectra on bilayer and trilayer graphene”, K. Sato, J. S. Park, C. Cong, T. Yu, R. Saito, 12th International Conference on the Science and Application of Nanotubes (NT11), Cambridge, United Kingdom, (2011.7.10-14).
7. “Carbon nanotubes as substrates for surface enhanced Raman spectroscopy”, C. Fantini, A. Righi, M.A. Pimenta, D. Andrada, A. Santos, C. Furtado, R. Saito, 12th International Conference on the Science and Application of Nanotubes (NT11), Cambridge, United Kingdom, (2011.7.10-14).
8. “Coherent phonon amplitudes of single wall carbon nanotubes”, A.R.T. Nugraha, R. Saito, Zao 11 Meeting, Yamagata-Zao, (2011.8.2-3).
9. “Raman spectroscopy of bilayer and trilayer graphene”, R. Saito, K. Sato, Zao 11 Meeting, Yamagata-Zao, (2011.8.2-3).
10. “Chirality-dependent coherent phonon amplitudes in carbon nanotubes: a closer look to the electron-phononinteraction”, A.R.T. Nugraha, K. Sato, R. Saito, 41th Fullerene Nanotube graphene symposium, Tokyo Met. Univ. (2011.9.5-7).
11. “Delay of Optical pulse in Fibonacchi photonic crystal”, R. Endo, R. Saito, J. Phys. Soc. Meeting, 2011 Fall meeting, Toyama Univ., (2011.9.21-24).
12. “Inihial Phase of Coherent Phonon in carbon nanotubes”, R. Saito, A.R.T. Nuguraha, K. Sato, J. Phys. Soc. Meeting, 2011 Fall meeting, Toyama Univ., (2011.9.21-24).
13. “Double resonance Raman Intensity of double and triple layer graphene”, K. Sato, R. Saito, J. Phys. Soc. Meeting, 2011 Fall meeting, Toyama Univ., (2011.9.21-24).
14. “Electron and phonon of graphene related materials (invited talk)”, R. Saito, A.R.T. Nugraha, K. Sato, K. Sasaki, C. Conxiao, Y. Ting, G. Dresselhaus, M.S. Dresselhaus, Tutorial in 2011 International Conference on Solid State Devices and Materials (SSDM 2011), Nagoya University, Nagoya, (2011.9.27).
15. “Coherent phonon spectroscopy of single wall carbon nanotubes (invited talk)”, R. Saito, PIRE kick-off meeting, Rice University, USA, (2011.10.7).
16. “Raman spectroscopy of graphene (invited talk)”, R. Saito, Seminar at Key Laboratory for Anisotropy and Texture of Materials, Tohoku University, ShenYang, China, (2011.11.2).

17. “Raman spectroscopy of graphene (invited talk)”, R. Saito, IMR Seminar, Institute of Metal Institute, ShenYang, China, (2011.11.2).
18. “Light pulse delay in a multi-layered photonic crystal”, R. Endo, R. Saito, The 17th Micro-Optics Conference, Sendai, Japan, (2011.11.1).
19. “Light pulse delay in a multi-layered photonic crystal”, R. Endo, R. Saito, 4th forum of Photonics, Sendai, Japan, (2011.11.16).
20. “Electron-phonon Interaction for Coherent Phonon Modes and Delay of Optical Pulse in Fibonacci Multilayers (invited talk)”, R. Saito, A. R. T. Nugraha, K. Sato, Endo, International Symposium on Terahertz Nanoscience (TeraNano 2011), Nakanoshima Center, Osaka, (2011.11.24-25).
21. “25 years of Nano Carbon research”, R. Saito, ATI 6th meeting, Advanced Technology Institute, (2011.12.9).
22. “Stacking order of double and triple layer graphene by Raman spectroscopy”, K. Sato, R. Saito, 2nd Nano-Carbon meeting, Advanced Technologh Institute (2011.12.9).
23. “Opposite gate voltage dependence of Raman spectra in graphene”, R. Saito, 2nd Nano-Carbon meeting, Advanced Technologh Institute (2011.12.9).
24. “Progress of Raman spectroscopy of carbon nanotubes (invited)”, R. Saito, Workshop on Carbon Nanotube in Commemoration of the 20th Anniversary of its Discovery (”2011 -CNT20”), The International House of Japan, Tokyo, (2011.12.12-13).
25. “Welcome to Carbon Nanotube world”, R. Saito, Misawa High school, Aomori (2011.12.21).
26. “Electric Raman spectra of single wall carbon nanotube”, 3rd ATI Nano-Carbon meeting. Advanced Technology Institute, Tamago-Yu Fukushima, (2012.1.30-31).
27. “Raman spectroscopy of few-layes graphenes and their edges (Invited talk)”, R. Saito, K. Sato, K. Sasaki, C. Cong, Y. Ting, G. Dresselhaus, M.S. Dresselhaus,2012.2.29-3.2, (Tokyo Institute of Technology).
28. “Raman spectroscopy of few layer graphene”, RIEC workshop on graphene, R. Saito, RIEC, Tohoku University, (2012.2.23).
29. “Phonon self-energy corrections to non-zero wavevector phonon modes in single-layer graphene”, P. T. Araujo, D. Mafra, K. Sato, R. Saito, J. Kong, M.S. Dresselhaus, APS March Meeting 2012, Boston, Massachusetts,(2012.2.27-3.2).
30. “Isotope impurity doping in graphene”, J. Rodriguez-Nieva, R. Saito, M.S. Dresselhaus, APS March Meeting 2012, Boston, Massachusetts, (2012.2.27-3.2).
31. “Using the G’ Raman cross-section to understand the phonon dynamics in bilayer graphene systems”, D. Mafra, P. T. Araujo, K. Sato, R. Saito, M.S. Dresselhaus, J. Kong,APS March Meeting 2012, Boston, Massachusetts,(2012.2.27-3.2).

32. “Raman spectroscopy of few-layers graphene and their edges (invited)”, R. Saito, K. Sato, K. Sasaki, C. Conxiao, Y. Ting, G. Dresselhaus, M.S. Dresselhaus, JSPS-DST Workshop on graphene and related materials, Tokyo Institute of Technology, (2012.2.29-3.2).
33. “Laser Power dependence of G’ Raman intensity in bilayer graphene”, R. Saito, K. Sato, D.L. Mafra, P.T. Araujo, M. S. Dresselhaus, The 42nd Fullerenes-Nanotubes-Graphene General Symposium, Takeda Frontier Science Hall, The University of Tokyo, (2012.3.6-8).
34. “Coherent phonon spectroscopy of RBM and RBLM phonons in carbon nanotubes and graphene nanoribbons”, A.R.T. Nugraha, G. Sanders, K. Sato, R. Saito, The 42nd Fullerenes-Nanotubes-Graphene General Symposium, Takeda Frontier Science Hall, The University of Tokyo, (2012.3.6-8).
35. “Inner and outer double Raman scattering process of graphene”, K. Sato, D.L. Mafra, P.T. Araujo, R. Saito, M.S. Dresselhaus, The 42nd Fullerenes-Nanotubes-Graphene General Symposium,
    Takeda Frontier Science Hall, The University of Tokyo, (2012.3.6-8).
36. “Enhancement and selection rules of near field optical transition in SWCNT”, P. Tapsanit, K. Sato, R. Saito, The 42nd Fullerenes-Nanotubes-Graphene General Symposium, Takeda Frontier Science Hall, The University of Tokyo, (2012.3.6-8).
37. “Double-fourth degeneracy in a quantum dot of nanotube”, W. Izumida, Anton Vikstrom, R. Saito, Japan Phys. Society meeting, 67th annual meeting, Kansei-gakuin Univ. (2012.3.24-27).
38. “Gate dependence of Raman spectra of single layer graphene”, R. Saito, K. Sato, P. T. Araujo, D.L. Marfa, M.S. Dresselhaus, Japan Phys. Society meeting, 67th annual meeting, Kansei-gakuin Univ. (2012.3.24-27).
39. “G band intensity for not regular stacked double layer graphene”, K. Sato, R. Saito. Japan Phys. Society meeting, 67th annual meeting, Kansei-gakuin Univ. (2012.3.24-27).

Name **Hitoshi Yamamoto**

Department **Physics**

Position **Professor**

Research Title **Electron-positron colliders**

I. Summary of Research

II. Publications

III. Presentations

Name **Toshihiro Kawakatsu**
Department **Physics**
Position **Professor**
Research Title **Study on structure and dynamics of soft matter**

I. Summary of Research

1. Development of hybrid particle-field simulation methods for bio-membranes and lipid solutions

We developed a coarse-grained hybrid simulation technique to study large scale and long time scale phenomena in polymer and surfactant systems. Our model is a combination of microscopic molecular dynamics simulation and self-consistent field theory. Using this hybrid technique, we succeeded in simulating bilayer membranes formed by DPPC lipid molecules [Publication 1] and micellar/cylindrical phases of this DPPD aqueous solutions [Publication 2]. We also proved that this hybrid approach can be highly parallelized so that an extraordinary large membrane system can be simulated [Publication 3].

2. Deformation of membranes induced by enclosed polymers

Using a field-theoretic approach, we study the equilibrium shape deformation of a vesicle induced by the presence of enclosed flexible polymers. This can be a model for drug delivery systems, endocytosis and polymer/surfactant solutions. By combining phase field theory for the membrane and self-consistent field theory for the polymers, we evaluated the free energy of the total system. The equilibrium membrane shape is determined by a competition between the bending elastic energy of the membrane and the conformation entropy of the polymers. We examined the dependence of the stability of the vesicle shape on the chain length of the polymers and the reduced volume of the vesicle. We present a simple model calculation that shows the relative stability of the prolate shape compared to the oblate shape [Publication 4].

3. Development of a hybrid approach for worm-like micellar systems

We developed a particle-field hybrid approach for worm-like micellar solutions, where molecular dynamics simulation is coupled with hydrodynamics described by Navier-Stokes equation. We succeeded in reproducing phase transition between gel phase and sol phase of the micellar solution, and studied the change in the rheological properties of the system across this transition [Publication 5].

II. Publications

1. “Hybrid Particle-Field Coarse-Grained Models for Biological Phospholipids”, A.De Nicola, Y. Zhao, T. Kawakatsu, D. Roccatano, and G. Milano, J. Chemical Theory and Computation,

7 (No.9) 2947-2962 (2011).

2. “Validation of a Hybrid MD-SCF Coarse-Grained Model for DPPC in Non-Lamellar Phases”, A.De Nicola, Y. Zhaoa, T. Kawakatsu, D. Roccatano and G. Milano, Theoretical Chemistry Accounts, in press.
3. “Hybrid Particle-Field Molecular Dynamics Simulations: Parallelization and Benchmarks”, Y. Zhao, A.De Nicola, T. Kawakatsu and G. Milano, J. Comput. Chem., 33 (No.8) 868-880 (2012).
4. “Deformation of Equilibrium Shape of a Vesicle Induced by Injected Flexible Polymers”, Y. Oya, K. Sato, and T. Kawakatsu, EPL, 94 (No.6) 68004 - p.1 -p.5 (2011).
5. “International Symposium on Non-Equilibrium Soft Matter 2010”, T. Kawakatsu, A. Matsuyama, T. Ohta, H. Tanaka, and S. Tanaka, edts., J. Phys.: Condens. Matt. 23 (No. 28) (2011).
6. “Research on Dynamics of Worm-like Micellar Solutions Using Partcle-Field Hybrid Method” (in Japanese), M. Toda and T. Kawakatsu, Bussei Kenkyu 96 (No.1) 77-78 (2011).

III. Presentations

1. “Dynamic Density Functional Theory for Structural Formation in Block Copolymer and Membrane Systems”, T. Kawakatsu, BIT's 1st Annual World Congress of Nano S&T (October 23 - 26, 2011, World EXPO Center, Dalian, China).
2. “Coarse-grained Models for Polymers and Surfactant Systems”, T. Kawakatsu, The 2nd international symposium on "Multi-scale Simulations of Biological and Soft Materials" (MSBSM 2011) (September 10 - 12, 2011, Shiran Kaikan, Kyoto, Japan).
3. “Hybrid Simulations for Polymer/Membrane Systems”, T. Kawakatsu, International Workshop for Molecular Simulations for Polymers (September 9, 2011, Obaku Plaza, Institute for Chemical Research, Kyoto University, Uji, Kyoto, Japan).
4. “Dynamic Self-Consistent Field Theory and Its Applications to Mesoscopic Structures in Polymer and Surfactant Systems”, T. Kawakatsu, DICP Symposium on Theoretical and Computational Chemistry (August 16-18, 2011, Center for Theoretical and Computational Chemistry (CTCC), Dalian Institute of Chemical Physics(DICP), Dalian, China).
5. “Hybrid approaches in density functional theories on polymer/membrane systems”, T. Kawakatsu, International Conference on the Hierarchical Structures in Complex Fluids (Jaly 4-8, 2011, Kavli Institute for Theoretical Physics China (KITPC), Beijing, China).

Name **Teruya Ishihara**
Department **Physics**
Position **Professor**
Research Title **Light-Matter interaction in metallic photonic crystals and metamaterials**

I. Summary of Research

II. Publications

III. Presentations

Name **Toshio Kobayashi**

Department **Physics**

Position **Professor**

Research Title **Study on Unstable Nuclides**

I. Summary of Research

II. Publications

III. Presentations

Name **Hajime Shimizu**
Department **Research Center for Electron Photon Science**
Position **Professor**
Research Title **Quark Nuclear Physics with a Photon Beam**

I. Summary of Research

Our research cannot get by without accelerators. Almost all of our activities were devoted in this fiscal year to recovering our accelerator facilities that had been seriously damaged by the Great East-Japan Earthquake (3.11 Disaster). The 300 MeV electron LINAC constructed in 1967 was in operation when the first blow came on and turned out later to be beyond hope of recovery, unfortunately. A huge amount of work and time was spent on cleaning up the facilities and disposing of junk. The first job was to take away collapsing concrete blocks of radiation shield which were placed everywhere around the accelerators in the basement, a total floor space of $3{,}526m^2$. We have removed about 500 shield blocks, the regular size of which is $0.5m \times 0.5m \times 2m$, out of the basement. Then about 3/4 of the 300 MeV LINAC has been disassembled and discarded. A large number of radiated components of wrecked accelerators have been classified, labeled, and kept properly in a radiation controlled area in the basement. This work was conducted down for small activated-parts including bolts and nuts. A united work by all of the laboratory staff made it possible to complete the psychologically exhausting job.

The last bunch of BGO crystals arrived in this fiscal year. We have finally 1320 BGO crystals, which are necessary to construct BGOegg, a 4π electromagnetic calorimeter. We got an energy resolution of 1.3% @1GeV for a 5×5 matrix of BGO crystals, part of the calorimeter, in an analysis for the data previously obtained using a positron beam in our laboratory before the 3.11 Disaster. Measured by utilizing a $^{137}C_s$ source set at several different places along the long axis of each crystal, the light output uniformity was found to be fairly good. Up to now, 480 BGO crystals have been mounted on the frame of BGOegg.

II. Publications

III. Presentations

Name	**Yasuhiro Sakemi**
Department	**Physics (Cyclotron and Radioisotope Center)**
Position	**Professor**
Research Title	**Study of the violation of time reversal invariance with the search for electron electric dipole moment measurements**

I. Summary of Research

1. The construction of the high intensity laser cooled radioactive atom factory was in progress to search for the electron electric dipole moment (EDM) using the francium (Fr), which is the radioactive atom, and has the maximum enhancement factor of the electron EDM with ~ 895. Due to damage of the cyclotron from the earthquake in 2011, the Fr production is stopped at present, but the test experiment to check the performance of the experimental apparatus will be done with the Rb beam.
2. The new thermal ionizer to produce and extract the Fr ions was developed to get a higher Fr intensity with the melted gold target. The Fr extraction efficiency with 35 % was achieved and it has the highest performance in the world to produce Fr. Another important component of the EDM experiment is the experimental apparatus to trap the Fr with laser. The laser light sources to cool and trap the Fr and also Rb which has the similar feature chemically as the Fr becomes ready with the development of external cavity diode laser system and TiS laser. Also we developed the magneto-optical traps and have succeeded in trapping Rb and transfer the Rb sample from one MOT to another MOT. Those are key techniques to perform the Fr EDM, and we will complete the experimental developments in 2012.

II. Publications

1. “Search for a permanent EDM using laser cooled radioactive atom.”
   Y. Sakemi et al. 2011. 6pp.
   Published in J.Phys.Conf.Ser.302:012051,2011.
2. “Electric dipole response in Sn-120.”
   Anna Maria Heilmann et al. 2011. 6pp.
   Prepared for 24th International Nuclear Physics Conference (INPC 2010), Vancouver, Canada, 4-9 July 2010.
   Published in J.Phys.Conf.Ser.312:092029,2011.
3. “Radiation hardness of optoelectronic components for the optical readout of the ATLAS inner detector.”
   S. Hou, (Taiwan, Inst. Phys.) , K. Ishii, (CYRIC, Tohoku U.) , M. Itoh, (CYRIC, Tohoku U.) ,

Y. Sakemi, (CYRIC, Tohoku U.) , D.S. Su, (Taiwan, Inst. Phys.) , T.T. Su, (Taiwan, Inst. Phys.) , P.K. Teng, (Taiwan, Inst. Phys.) , H.P. Yoshida, (CYRIC, Tohoku U.) . 2011.
Published in Nucl.Instrum.Meth.A636:S137-S142,2011.

4. "High-resolution study of Gamow-Teller transitions via the Fe-54 (He-3, t) Co-54 reaction."
T. Adachi et al. Feb 2012. (Received Feb 2012). 15pp.
Published in Phys.Rev.C85:024308,2012.

III. Presentations

1. "Search for permanent electric dipole moment in Francium"
H. Kawamura
International workshop on Fundamental Physics using Atoms : FPUA2011, (October 8-10, 2011, Okayama University, Okayama, Japan)
2. "Searches for a permanent EDM using laser cooled radioactive atoms"
H.P. Yoshida
International conference on Advances in Radioactive Isotope Science : ARIS 2011 (May-29~June 3, 2011, Leuven, Belgium)

Name **Kazuyoshi Yamada**
Department **Physics, and WPI-AIMR**
Position **Professor**
Research Title **Neutron scattering studies on Cuprate Superconductors**

I. Summary of Research

1. We have performed inelastic neutron scattering using pulsed neutrons at ISIS Rutherford Appleton Laboratory on high transition temperature (high-T_c) superconducting cuprate $La_{1.85}Sr_{0.15}Cu_{0.97}Ni_{0.03}O_4$ to study magnetic Ni-impurity effect on hourglass dispersion observed commonly in hole-doped high-T_c cuprates. We found that 3% of magnetic impurity Ni does change magnetic dispersion and shift the waist of hourglass dispersion down to 20meV. This change induced by magnetic impurity strongly indicates that the shape of hourglass dispersion is dominated mainly by magnetic interaction, which should be taken into account to build theory of high-T_c superconductors.
2. We have studied slow lattice dynamics in relaxor ferroelectric compound $0.7Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.3PbTiO_3$ with using backscattering spectrometer BASIS installed at SNS Oak Ridge National Laboratory. We revealed a novel lattice vibration at 40meV which is 10 times lower frequency compared to that of the lowest phonon branch. Such low-energy mode indicates soft lattice, which is closely correlate with the giant dielectric response observed in relaxor ferroelectrics.
3. Antiferromagnetic spin fluctuations in doped Mott insulators are widely believed to play a fundamental role in the mechanism of high-transition-temperature superconductivity. A finding of similar feature in the overall dispersive excitations of $La_{1.875}Ba_{0.125}CuO_4$ (La214) and $YBa_2Cu_3O_{6.6}$ attracts much attention due to the potential role of spin fluctuations in the high-T_c mechanism. To extract universal nature of the spin excitation spectrum in high-T_c cuprates, it is useful to study appropriate reference systems. We, hence, performed high-energy neutron-scattering measurement on $Bi_{2+x}Sr_{2-x}CuO_{6+d}$ (Bi2201) system. It was clarified that in the non-superconducting x=0.4(hole concentration p~0.06) sample the high-energy spin excitation is highly overdamped in the energy and momentum spaces, unlike to the observation of well-defined spectrum in La214. Since further doping makes the spectrum obscure in the superconducting region, the present result suggests the importance of high-frequency local spin dynamics for the superconducting mechanism.

II. Publications

1. "Incommensurate Spin Fluctuations in Hole-Overdoped Superconductor KFe_2As_2",
   C. H. Lee, K. Kihou, H. Kawano-Furukawa, T. Saito, A. Iyo, H. Eisaki, H. Fukazawa, Y. Kohori, K. Suzuki, H. Usui, K. Kuroki and K. Yamada,
   Phys. Rev Lett. 106 (2011) 067003(1)- 067003(4)
2. "Orbital Ordering of Intermediate-Spin State of Co^{3+} in $Sr_3YCo_4O_{10.5}$",
   H. Nakao, T. Murata, D. Bizen, Y. Murakami, K. Ohoyama, K. Yamada, S. Ishiwata, W. Kobayashi, and I. Terasaki,
   J. Phys. Soc. Jpn 78 (2011) 023711(1)- 023711(4)
3. "Plastically Deformed Si-crystal Wafers for Neutron-Monochromator Elements",
   H. Hiraka, K. Fujiwara, K. Yamada, K. Morishita and K. Nakajima,
   Nucl. Inst. Methods Phys. Res. A 635 (2011) 137-140
4. "Imaging Doped Holes in a Cuprate Superconductor with High-Resolution Compton Scattering",
   Y. Sakurai, M. Itou, B. Barbiellini, P. E. Mijnarends, R. S. Markiewicz, S. Kaprzyk, J.-M. Gillet, S. Wakimoto, M. Fujita, S. Basak, Yung Jui Wang, W. Al-Sawai, H. Lin, A. Bansil, and K. Yamada,
   Science 332 (2011) 698-702
5. "Possible Link of a Structurally Driven Spin Flip Transition and the Insulator-Metal Transition in the Perovskite $La_{1-x}Ba_xCoO_3$",
   P. Tong,1 J. Yu,1 Q. Huang, K. Yamada and D. Louca,
   Phys. Rev Lett. 106 (2011) 067003(1)- 067003(4)
6. "Characterization of Glasses for 3He Neutron Spin Filter Cells",
   Y. Sakaguchi, H. Kira, T. Oku, T. Shinohara, J. Suzuki, K. Sakai, M. Nakamura, K. Suzuya, M. Arai, M. Takeda, S. Wakimoto, D. Yamazaki, S. Koizumi, Y. Endoh, K. Kakurai, Y. Arimoto, T. Ino, H.M. Shimizu, T. Kamiyama, K. Ohoyama, H. Hiraka, K. Tsutsumi, K. Yamada, L.J. Chang,
   Nucl. Inst. Methods Phys. Res. A 6354 (2011) S122-S125
7. "Doping Dependence of the (π, π) Shadow Band in La-Based Cuprates Studied by Angle-Resolved Photoemission Spectroscopy",
   R-H He, X J Zhou, M Hashimoto, T Yoshida, K Tanaka, S-K Mo, T Sasagawa, N Mannella, W Meevasana, H Yao, M Fujita, T Adachi, S Komiya, S Uchida, Y Ando, F Zhou, Z X Zhao, A Fujimori, Y Koike, K Yamada, Z Hussain and Z-X Shen,
   New J. Phys. 13 (2011)013031(15)

8. "Low-Energy Quasi-One-Dimensional Spin Dynamics in Charge-Ordered $La_{2-x}Sr_xNiO_4$",
   P. G. Freeman, D. Prabhakaran, K. Nakajima, A. Stunault, M. Enderle, C. Niedermayer, C. D. Frost, K. Yamada, and A. T. Boothroyd,
   Phys. Rev. B 83 (2011) 094414(1)-094414(6)
9. "Progress in Neutron Scattering Studies of Spin Excitations in High-Tc Cuprates",
   M. Fujita, H. Hiraka, M. Matsuda, M. Matsuura, J. M. Tranquada, S. Wakimoto, G. Xu, and K. Yamada,
   J. Phys. Soc. Jpn 81 (2011) 011007(19)

III. Presentations

1. "Neutron Scattering Study of Magnetic Impurity-Fe Effect on hourglass-like magnetic dispersions in La-based high-Tc cuprate", M. Matsuura, The 66th Annual Meeting of Japan Physical Society, March 24, 2012, Kwansei-Gakuin University, Hyogo, Japan (in Japanese)
2. "Spin Excitations in single layer Bi2201 Superconductor", M. Fujita, M. Enoki, S. Iikubo, C. D. Frost, K. Yamada, 5th European Conference on Neutron Scattering, 18 July 2011, Czech, Prague
3. "Doping evolution of spin correlation in Bi2201", International Conference on Novel Super Conductivity , M. Fujita, 6 August 2011, Tainan, Taiwan
4. "Ho-doping effect on the static stripe order in La214 superconductor", M. Fujita, M. Enoki, S. Iikubo, M. Matsuura, K. Yamada, International Conference on Novel Super Conductivity 9 August 2011, Tainan, Taiwan
5. "Magnetic excitation in electron-doped antiferromagnet $Pr_{1.32}La_{0.6}Ce_{0.08}CuO_4$", M. Fujita, K. Shigiya, K. Yamada, Meeting of Physical Society of Japan, 22 September 2011, Toyama, Japan
6. "Use of pulsed-neutron scattering techniques for a study of high-Tc cuprate", M. Fujita, CROSS Workshop : CROSSROAD of Users and J-PARCJPS, 17 Octorber 2011, Tokai, Ibaraki
7. "Doping evolution of spin correlation in Bi2201", M. Fujita, 2011 Gordon Godfrey Workshop on Spins and Strong Correlations , 26 Octorber 2011, Sydney, Australia
8. "Spin Excitation in Electron-Doped Cuprate Oxide", M. Fujita, K. Tsutsumi, T. Sasaki, K. Shigiya, J. Kaminaga, M. Nakagawa, M. Enoki, M. Matsuura, K. Yamada, 1st Asia-Oceania Conference on Neutron Scattering, 21 November 2011, Tsukuba, Japan

Name	**Takashi Takahashi**
Department	**Physics, and WPI-AIMR**
Position	**Professor**
Research Title	**Ultrahigh-resolution photoemission study of topological insulators and novel superconductors**

I. Summary of Research

1. We have performed angle-resolved photoemission spectroscopy on $TlBi(S_{1-x}Se_x)_2$, and found that this system goes through a quantum phase transition from topological to non-topological phase. We revealed that the massless Dirac state switches to a massive state before it disappears in the non-topological phase. The results suggest that Dirac electrons acquire a mass through spontaneous symmetry breaking.
2. By using high-resolution ARPES, we have demonstrated that simultaneous tuning of the Sb and Se contents in $Bi_{2-x}Sb_xTe_{3-y}Se_y$ makes it possible to control the energy location of the surface Dirac cone and the sign of Dirac carriers while keeping the bulk insulating character. Such a tunable Dirac cone opens a promising pathway to the development of novel devices based on topological insulators.
3. We have performed ultrahigh-resolution ARPES on iron-pnictide superconductor, and found that the superconducting gap size scales linearly with T_c. We also revealed that a distinct pseudogap coexisting with the superconducting gap develops on underdoping, similarly to the observation in copper-oxide superconductors. The result raises the possibility for a unifying picture of high-T_c superconductivity between iron-pnictide and copper-oxide superconductors.

II. Publications

1. "Topological surface states in lead-based ternary telluride $Pb(Bi_{1-x}Sb_x)_2Te_4$",
   S. Souma *et al.*, Phys. Rev. Lett., in press.
2. "Tunable Dirac cone in the topological insulator $Bi_{2-x}Sb_xTe_{3-y}Se_y$",
   T. Arakane *et al.*, Nat. Commun., 3, 636, (2012).
3. "Unconventional anisotropic s-wave superconducting gaps of the LiFeAs iron-pnictide superconductor",
   K. Umezawa *et al.*, Phys. Rev. Lett., 108, 037002, (2012).
4. "Fe-based superconductors: an angle-resolved photoemission spectroscopy perspective",
   P. Richard *et al.*, Rep. Prog. Phys., **74**, 124512, (2011).
5. "Unconventional superconducting gap in $NaFe_{0.95}Co_{0.05}As$ observed by angle-resolved

photoemission spectroscopy",
Z.-H. Liu *et al.*, Phys. Rev. B, **84**, 064519, (2011).

6. "Unexpected mass acquisition of Dirac fermions at the quantum phase transition of a topological insulator",
T. Sato *et al.*, Nature Phys., **7**, 840, (2011).
7. "Fermi surface dichotomy of the superconducting gap and pseudogap in underdoped pnictides",
Y.-M. Xu *et al.*, Nat. Commun., **2**, 392, (2011).
8. "Photoemission study of electronic structure evolution across the metal-insulator transition of heavily B-doped diamond",
H. Okazaki *et al.*, J. Phys. Chem. Solids, **72**, 582, (2011).
9. "Two pseudogaps with different energy scales at the antinode of the high-temperature $Bi_2Sr_2CuO_6$ superconductor using angle-resolved photoemission spectroscopy",
K. Nakayama *et al.*, Phys. Rev. B, **83**, 224509, (2011).
10. "Direct measurement of the out-of-plane spin texture in the Dirac cone surface state of a topological insulator",
S. Souma *et al.*, Phys. Rev. Lett., **106**, 216803, (2011).
11. "Evolution of surface states in $Bi_{1-x}Sb_x$ alloys across the topological phase transition",
H. Guo *et al.*, Phys. Rev. B, **83**, 201104(R), (2011).
12. "Giant out-of-plane spin component and the asymmetry of spin-polarization in surface Rashba states of bismuth thin film",
A. Takayama *et al.*, Phys. Rev. Lett., **106**, 166401, (2011).
13. "Angle-resolved photoemission study of doping evolution of three-dimensional Fermi surface in Na_xCoO_2",
T. Arakane *et al.*, New J. Phys., **13**, 043021, (2011).

III. Presentations

1. "Development of high-resolution spin-resolved ARPES spectrometer and study on electronic structure of novel high-functional material" (invited),
Seigo Souma, JPS the 66th annual meeting, (March 24-27, 2012, Kwansei Gakuin University, Nishinomiya, Japan).
2. "High-resolution ARPES on graphite intercalation compounds" (invited),
Katsuaki Sugawara, The 3rd Workshop on Regulated Nanospace, (March 22-23, 2012, Tokyo institute of Technology, Tokyo, Japan).
3. "High-resolution ARPES study of topological insulators" (invited),
Takafumi Sato, 29th PF symposium, (March 15-16, 2012, Tsukuba international congre

ss center, Tsukuba, Japan).

4. “Electronic structure of epitaxial graphene film and related materials studied by high-resolution ARPES” (invited),
   Katsuaki Sugawara, JSPS Bilateral Joint Projects/Seminars, (February 29 - March 2, 2012, Tokyo institute of Technology, Tokyo, Japan).
5. “Unexpected mass acquisition of Dirac fermions in topological insulators revealed by ARPES” (invited),
   Takafumi Sato, Workshop on surface electronics states of topological insulators, (February 23-24, 2012, ISSP, Univ. of Tokyo, Chiba, Japan).
6. “Direct measurement of the out-of-plane spin texture in the Dirac cone surface state of a topological insulator” (invited),
   Seigo Souma, The 2012 WPI-AIMR annual workshop, (February 20-23, 2012, Sendai international center, Sendai, Japan).
7. “Anomalous Rashba effect of Bi(111) thin film studied by high-resolution spin-resolved ARPES" (oral)
   Akari Takayama, 39th Conference on the Physics and Chemistry of Surfaces and Interfaces (PCSI), (January 22-26, 2012, Santa Fe, New Mexico, USA).
8. “High-resolution spin-resolved ARPES on topological insulator” (invited),
   Seigo Souma, The 31th annual meeting of the surface science society of Japan, (December 15-17, 2011, Tower Hall Funabori, Tokyo, Japan).
9. “High-resolution ARPES on graphene and graphene intercalated compounds” (invited),
   Katsuaki Sugawara, The 31th annual meeting of the surface science society of Japan, (December 15-17, 2011, Tower Hall Funabori, Tokyo, Japan).
10. “Study of spintronics materials by high-resolution spin-resolved ARPES” (invited),
    Akari Takayama, Symposium on Surface Science and Nano-Material Science with Synchrotron Radiation, (November 25-26, 2011, Osaka Electro-Communication University, Osaka, Japan).
11. “Topological quantum phase transition of $TlBi(S_{1-x}Se_x)_2$ studied by ARPES” (invited),
    Seigo Souma, International Workshop for Young Researchers on Topological Quantum Phenomena in Condensed Matter with Broken Symmetries, (November 1-5, 2011, Lafo ret Biwako, Shiga, Japan).
12. “Dirac fermions in iron-based superconductors” (invited),
    Takafumi Sato, JPS the 65th annual meeting, (September 21-24, 2011, Toyama University, Toyama, Japan).
13. “ARPES study of pseudogap in cuprates” (invited),

Kosuke Nakayama, JPS the 65th annual meeting, (September 21-24, 2011, Toyama University, Toyama, Japan).

14. “Development of ultrahigh-resolution bulk-sensitive spin-resolved photoemission spectrometer” (invited),
    Seigo Souma, JAIMA expo 2011, Frontier of Analytical Technology, (September 7-9, 2011, Makuhari Messe, Japan).
15. “Superconducting gap and pseudogap in Fe-based superconductors” (invited),
    Kosuke Nakayama, ICC-IMR2011 “Search for new physics in transition metal compounds by spectroscopies”, (July 28-30, 2012, Tohoku University, Sendai, Japan).
16. “Direct observation of superconducting gap in Fe-based superconductors” (invited),
    Kosuke Nakayama, International Workshop on Strong Correlations and Angle-Resolved Photoemission Spectroscopy, (July 18-22, 2011, Berkeley, California, USA).

III. Prizes (Awards)

1. Award of Editor’ Choice for “Tunable Dirac cone in the topological insulator Bi2-xSbxTe3-ySey”, Nature Communications 3 : 636 doi: 10.1038/ncomms1639, (January 24, 2012)

Seigo Souma (Assistant Prof.), Young Scientist Award of the Physical Society of Japan for the study on “Development of high-resolution spin-resolved ARPES spectrometer and study on electronic structure of novel high-functional material”, (March 27, 2012).

Akari Takayama (D2), Chika Kuroda Prize for the study on “Development of ultrahigh-resolution spin-resolved photoemission spectrometer and study of anomalous Rashba effect of Bi(111)”, Graduate School of Science, Tohoku University, (March 19, 2012).

Name **Katsumi Tanigaki**
Department **Physics, and WPI-AIMR**
Position **Professor**
Research Titles **1. Materials with regulated nano spaces: light-element strategy**
2. Carbon materials
3. Dirac-cone quantum states on topological consideration
4. Molecular semiconductors: Fundamentals in device physics

I. Summary of Research

We have been currently exploring new materials targeting on innovative materials in nano scale for future technology. By employing nano structure, intriguing physical properties such as high transport mobility, high temperature superconductivity and high efficient thermoelectricity can be anticipated. A new paradigm approaching for new materials science and technology will open a new route to develop various materials, based on which we can develop new devices and new scientific concept.

1. Materials with regulated nano spaces: Strategy on Ubiquitous element

Cage compounds with nano spaces inside become excellent thermoelectric materials for converting heat into electricity. This comes from the large suppression in heat conductivity without losing high electric conductivity. This contradictory relationship necessary for thermoelectrics cannot be realized in a standard materials, as well known to be Wiedemann-Franz Law. However, anharmonic phonons created by motions of endohedral atoms inside the cage greatly scatter acoustic phonons to reduce the thermal conductivity in a similar fashion observed in amorphous materials, while electric conductivity is not influenced because the Fermi surface can mainly be constructed by the wavefunctions of elements residing on the cage. This concept was proposed by Sales et al. in 2001 and now is one of the promising methodologies for making high efficient thermoelectric compounds. Another intriguing issue for anharmonic phonons is how greatly they can strengthen electron-phonon coupling interactions. Although many experimental approaches had been made in the past, the data so far obtained are different among the reports and the debate continues without consensus. We have made a new approach for making accurate determination of the coupling strength by separating between the γT Sommerfeld electron and the atomic phonon αT (mostly related to the tunneling process) parts, both of which show temperature (T) linear dependence, by changing carrier concentration. As a result, we have figured out that the electron-phonon coupling strength in the case of anharmonic phonons of clathrates can be elevated by 1.8 times as high as that in the case of normal harmonic phonons. This finding is very important for understanding the

mechanism of superconductivity mediated by anharmonic phonons as well as for designing new thermoelectric materials.

2. Carbon materials

Carbon materials are very important from the scientific point of views. Especially the superconductivity recently found in picene as well as in other fused ring systems is intriguing, but the reproduced experiments are still scientifically warranted. In order to understand the situation fundamentally, we have resurveyed the structure and the physical properties of potassium-doped anthracene, tetracene and pentacene phases, the most fundamental fused-ring analogues, with the 1 : 1 stoichiometry in order to study whether the half-filled states of this system is a Mott state or a localized one. Ever since many studies have been made in the past decades, the answer to this fundamental reply has yet been clarified. We have successfully found a new methodology of synthesizing high quality doped phases. Antimagnetic interactions have been confirmed in the case of anthracene, while the other two systems are almost nonmagnetic. We expect that further studies will provide a useful information on the nature of these doped systems.

3. New superconductors: synthesis and physical properties

Topology in materials is of large scientific interest after the discovery of intriguing quantum states of graphene, the 2010 Nobel Prize in physics. The quantum states of the Dirac-cone fermions as well as the topological insulators showing nontrivial metallic surface states have become one of the most attractive materials science to date. Dirac-cone electronic states originally discussed in graphene are now more popular in other materials, such as some of Bi compounds, organic conductors and the parent compound of FeAs superconductors. Especially, the Dirac-cone states recently predicted theoretically and observed by ARPES for $Ba(FeAs)_2$ are very curios since they are classified as a d-multiband Dirac-cone system. We have demonstrated experimentally in the first time that a linear evolution of magneto-resistance as a function of magnetic field, which has been predicted by Abricosov for the Dirac-cone states in the past, has been observed via transport measurements and that electron and hole Dirac-cones coexist in pairs in this multiband system. The multiband Dirac-cone quantum states are scientifically very curious, and further experimental and theoretical studies are presently in progress.

4. Molecular semiconductors: Fundamentals in device physics

Metal-semiconductor contact between the active layer and the electrodes has been one of the very important scientific issues in the field of semiconductor technology. Two extreme limits, the Schottky limit and the Bardeen one, are generally known. The Schottky barrier height depends on

the workfunction of the metal electrodes (φ_m) in the former case, while it is nearly independent in the latter case. The metal-semiconductor contact becomes more important when one thinks about organic light-emitting field effect transistors (OLETs). Different from inorganic semiconducting materials, ambipolar carrier injection of electrons and holes has recently been known to be possible in organic semiconducting materials most likely due to their non-dangling bonding characters stemming from π-conjugated interfacial states. However, the contact of the metal-semiconductor interface of organic semiconductors can in general be classified to the Schottky limit and the conduction band minima (CBM) is apart from the Fermi level (E_F) of the conventional electrode metals, such as gold and copper. As a consequence, metals with low workfunctions must be used as an electrode in order to inject electron carriers. The OLET devices thus prepared are air sensitive and operate only under an anaerobic condition.

Although the metal-semiconductor contact of organic semiconductors is generally categorized in the Schottky limit, the contact is very sensitive to the surface condition of organic semiconductors. We found that the meal-semiconductor contact can be changed from the Schottky limit to the Bardeen one without large reduction in carrier mobility. We have successfully demonstrated that the silicon dioxide gate insulator was modified by aliphatic chain hydrocarbon molecules FETs with Au electrodes showed a very different transfer characteristic from what was conventionally observed. The almost equal injection of electrons and holes with holding high mobilities was achieved regardless of the fact that the Fermi level of Au is very different from that of CBM and nearly the same as that of VBM, being in correspondence with the concept of the Bardeen limit.

II. Publications

1. G. Mu, J. Tang, Y. Tanabe, J.-t Xu, S. Heguri, and K. Tanigaki, “Evidence for line nodes in the energy gap of the overdoped $Ba(Fe_{1-x}Co_x)_2As_2$ from low-temperature specific heat measurements”, Phys. Rev. B 84, 2011.
2. Y. Tanabe, K. K. Huynh, S. Heguri, G. Mu, T. Urata, J. Xu, R. Nouchi, N. Mitoma, and K. Tanigaki, “Coexistence of Dirac-cone states and superconductivity in iron pnictide $Ba(Fe_{1-x}RuxAs)_2$”, Phys. Review B, 84, 100508 (2011).
3. J. Tang, J. T. Xu, S. Heguri, K. Akai and K. Tanigaki, “Valence Band Studies of p- and n-Type Ba(8)Ga(16)Ge(30) Using High-Resolution Photoelectron Spectroscopy”, J. of Elect. Materials 40, 769-772 (2011).
4. J.-t Xu, J. Tang, K. Sato, Y. Tanabe, S. Heguri, H. Miyasaka, M. Yamashita and K. Tanigaki, “Heat Capacity Study on Anharmonicity in $Ae_8Ga_{16}Ge_{30}$ (Ae = Sr and Ba)”, J. Elect. Materials 40, 879-883 (2011).
5. K. K. Huynh, Y. Tanabe Yoichi and Tanigaki Katsumi, “Both Electron and Hole Dirac-Cone

States in Ba(FeAs) Confirmed by Magnetoresistance", Phys. Rev. Lett. 106, 217004 (2011).

6. R. Nouhci, T. Saito, and K. Tanigaki, "Determination of Carrier Type Doped from Metal Contacts to Graphene by Channel-Length-Dependent Shift of Charge Neutrality Points", Appl. Physics Express 4, 035101 (2011).
7. F. Xiaoyan, N. Ryo and Katsumi Tanigaki, "Effect of Charge Puddles and Ripples on the Chemical Reactivity of Single Layer Graphene Supported by SiO_2 Si Substrate", J. Phys. Chem. C 115 , 12960-12964 (2011).
8. Nouchi Ryo and Tanigaki Katsumi, "Empirical Modeling of Metal-Contact Effects on Graphene Field-Effect Transistors", Jap. J. Appl. Phys. 50, 07010 (2011).

III. Presentations

1. K. Tanigaki, Fundamentals and applications in carbon devices; centering on graphene, 30th Electronic Materials Symposium, June 29-July 1, 2011, Shiga, Japan, Invited.
2. K. Tanigaki, New Materials Science, Strategy on Ubiquitous Elements, 5th Joint symposium on Materials Science, November 19-20, 2011, Sendai, Japan (Invited).
3. K. Tanigaki, International Symposium of New Materials Science: Strategy on Ubiquitous Elements, November 24-26, 2011, Sendai, Japan.
4. K. Tanigaki, Strategy on elements, Electronic materials from the viewpoint of topological insulators, Joint meeting between experiments and calculations, December 5, 2011, Tokyo University, Japan (Invited).
5. K. Tanigaki, What can be influenced by discovery of a new type of carbon: fullerenes, nanotube and graphene, 10th Co-memorial International Symposium on Nanotubes, December 12-13, 2011, Tokyo, Japan (Invited).
6. K. Tanigaki, Bardeen limit and Schottky limit of metal-semiconductor contacts and ambipolar carrier injection in light emitting organic FETs, Katsumi Tanigaki, Tohoku-UCSB Workshop, January 10-11, 2012, Santa Barbara, CA, USA.
7. K. Tanigaki, J.-T. Xu, Y. Tanabe, M. Gang, and S. Heguri, Endohedral intercalations of silicon and germanium clathrates and thermoelectric applications, ISIC16, May 22-27, 2011, Praha, Czech.
8. J.-T. Xu, J. Wu, S. Heguri, Y. Tanabe, M. Gang, J. Tang, and K. Tanigaki, Different physical properties in n/p- $Ba_8Ga_{16}Ge_{30}$", ICT2011, July 17-21, 2011, Traverse City, MI, U.S.A.
9. N. Yamada, R. Nouchi and K. Tanigaki, Channel-Length Dependent Shift of Threshold Voltages in Organic Field-Effect Transistors, ECME2011, September 7-10, 2011, Barcelona, Spain.
10. R. Nouchi, M. Shigeno, N. Yamada, Masahiko Yamaguchi and K. Tanigaki, Reversible

Schottky-Ohmic Switching at Metal/Organic-Semiconductor Interfaces, ECME2011, September 7-10, 2011, Barcelona, Spain.

11. S. Ikeda, K. Thangavel, R. Kumashiro, T. Inoue, H. Shang, D. Hirota, H. Shimotani, and K. Tanigaki, Explorations of Effective Factors for Optimizing Light-Emitting Organic Field-Effect Transistors, 2011 Fall MRS meeting, November 28-December 2, 2011, Boston, MA, U.S.A..
12. J. Ikeda, Q. T. Phan, S. Ikeda, R. Nouchi, Y. Tanabe, H. Shimotani, and K. Tanigaki, Negative Transconductance in Organic Single Crystal Transistors Gated by Room-Temperature Ionic Liquids, 2011 Fall MRS meeting, November 28-December 2, 2011, Boston, MA, USA..
13. M. Gang, J. Tang, Y. Tanabe, J.-T. Xu, S. Heguri, and K. Tanigaki, Evidence for line nodes in the energy gap of overdoped $Ba(Fe_{1-x}Co_x)_2As_2$: A low-temperature specific heat study, APS March Meeting 2012, February 27-March 2, 2012, Boston, MA, USA.
14. Y. Tanabe, H. K. Khuong, T. Urata, R. Nouchi, N. Mitoma, S. Heguri, J.-T. Xu, M. Gang, and K. Tanigaki, Ru Doping Effect on the Dirac Cone State and the Possible Coexistence of the Dirac Cone state and the Superconductivity in $Ba(Fe_{2-x}Ru_xAs)_2$, LT26-Beijing2011, August 11-17, 2011, Beijing, China.
15. K. K. Hyunh Y. Tanabe, T. Urata, R. Nouchi, N. Mitoma, S. Heguri, X. Jingtao, M. Gang and K. Tanigaki, Evidence for Quantum Magnetotransport of Dirac Cone States in $Ba(FeAs)_2$, LT26-Beijing2011, August 11-17, 2011, Beijing, China.
16. Y. Tanabe, H. K. Khuong, S. Heguri, M. Gang, X. Jingtao, T. Urata, R. Nouchi, N. Mitoma and K. Tanigaki, Possible Coexistence of the Dirac Cone State and the Superconductivity in $Ba(FE2\text{-}xRUxAs)_2$, ICNSCT2011, August 5-8, 2011, Tainan, Taiwan.

11. Y. Tanabe, H. K. Khuong, S. Heguri, M. Gang, J.-T. Xu, T. Urata, R. Nouchi, N. Mitoma and K. Tanigaki, Suppression of the backward scattering of Dirac Fermion in iron pnictides $Ba(Fe_{1-x}Ru_xAs)_2$, International Conference of New Science Created by Materials with Nano Space: From Fundamentals to Applications, November 23-26, 2011, Sendai, Japan.
12. J.-T. Xu, Y. Tanabe, S. Heguri, J. Wu, M. Gang, J. Tang and K. Tanigaki, Heat capacity studies on anharmonic motions in type I clathrates, International Conference of New Science Created by Materials with Nano Space: From Fundamentals to Applications, November 23-26, 2011, Sendai, Japan.
13. S. Nakano, R. Kumashiro, K. Tanigaki, Y. Imaeda, T. Nakamoto, K. Funahashi, T. Kume, T. Kikegawa, N. Hirao, Y. Ohishi, X-ray powder diffraction measurement on $Ba_{24}Ge_{100}$ under high-pressure/low-temperature using helium pressure medium, International Conference of New Science Created by Materials with Nano Space: From Fundamentals to Applications, (November 23-26, 2011, Sendai, Japan.

14. G. Mu, J. Tang, Y. Tanabe, J.-T. Xu, S. Heguri and K. Tanigaki, Evidence for line nodes in the energy gap of overdoped $Ba(Fe_{1-x}Co_x)_2As_2$ single crystals from low-temperature specific heat measurements", International Conference of New Science Created by Materials with Nano Space: From Fundamentals to Applications, November 23-26, 2011, Sendai, Japan.
15. T. Kanagasekaran, S. Ikeda, R. Kumashiro, H. Shimotani and K. Tanigaki, Air stable organic light emitting field effect transistor with gold electrodes, International Conference of New Science Created by Materials with Nano Space: From Fundamentals to Applications, (November 23-26, 2011, Sendai, Japan).

IV. Prizes (Awards)

Hidekazu Shimotani, Associate Professor of Nano Solid-State Laboratory, Young Scientist Award of the Physical Society of Japan, Scientific field 7 (March 24, 2011).

Name **Hideo Kozono**
Department **Mathematics**
Position **Professor**
Research Title **Nonlinear Analysis**

I. Summary of Research

II. Publications

IV. Presentations

Name **Motoko Kotani**
Department **Mathematics**
Position **Professor**
Research Title **Mathematical challenge to a new phase of materials science**

I. Summary of Research

1. Hidden mechanism in the growth of cubic Rh clusters is revealed by a newly developed mathematical design theory, "Euclidean Design". This is the first application of this advanced mathematics to atomic cluster science as a powerful tool to optimize the geometrical structure.
2. Density of states of a 1-dimensional carbon nano-tube with curvature is studied in terms of its geometry.
3. Collaboration with chemistry group to develop new nanosecond structured illumination microscopy by application of the mathematical theory of quasi crystal and generalized Fourier transform.

II. Publications

1. M. Tagami, Y. Y. Liang, Y. Kawazoe, M. Kotani: "New Growth Mechanism of Cubic Rh Clusters Composed of 8-12 Atoms Found by Euclidean Designs", Materials Transactions 53 no.3 (2012), 459-462

III. Presentations

1. "A Mathematical challenge to a new phase of materials science",
   Motoko Kotani, 2nd May, 2011, KIAS, Seoul, Korea.
2. "A Mathematical challenge to a new phase of materials science",
   Motoko Kotani, 7th Sep. 2011, CREST symposium, Akihabara, Tokyo, Japan.
3. "A Mathematical challenge to a new phase of materials science",
   Motoko Kotani, 30th Jan.2012, Hokkaido University, Sapporo, Japan.
4. "A Mathematical Challenge to a new phase of materials science",
   Motoko Kotani, 29th Feb, 2012, MANA Symposium 2012, MANA, Tsukuba, Japan.
5. "A Mathematical Challenge to a new phase of materials science",
   Motoko Kotani, 29th Mar.-30th Mar. 2012, Japan-German Hexagon alliance meeting, Kyoto, Japan.
6. "Science and Technology Policy in Japan",
   Motoko Kotani, 5th Dec. 9th Dec.2011, Emerging Topics on Differential Equations and their Applications,-Sino-Japan Conference of Young Mathematicians, Nankai Univ. China.

7. “Science and Technology Policy in Japan”,
   Motoko Kotani, the ESF-JSPS Frontier Science Conference, 28th Feb.-4th Mar.2012, Tokyo, Japan.
8. “Development of nanosecond structured illumination microscopy for the observation of periodic nano-structures in solution”,
   Shuichi Toyouchi, Shinji Kajimoto, Kenta Kitabatake, Hiroshi Fukumura,Takanobu Kamijo, Yohji Akama, Motoko Kotani, 26th Jun.-1st Jul. 2011, International Conference on Materials for Advanced Technologies, Suntec, Singapore.

IV. Prizes (Awards)

1. Honor of the distinguished professor in Tohoku University.

Name **Reiko Miyaoka**
Department **Mathematics**
Position **Professor**
Research Title **Hypersurface geometry and symplectic geometry**

I. Summary of Research

1. I characterized the Cartan-Muenzner polynomial of degree four in terms of the moment map of the spin action.
2. I investigated transnormal and isoparametric functions on general Riemannian manifolds.

II. Publications

1. “Isoparametric hypersurfaces with (g,m)=(6,2)”,
   R. Miyaoka, Annals of Math., vol .176 (2012), to appear.
2. “Moment maps of the spin action and the Cartan-Muenzner polynomials of degree four”,
   R. Miyaoka, submitted (2011).
3. “Transnormal functions on a Riemannian manifold”,
   R. Miyaoka, submitted (2012).
4. “Transnormal hypersurfaces, TN systems and TN functions”,
   R. Miyaoka, Geometry and Something (in Japanese), 2012.

III. Presentations

1. “Moment maps of the spin action and the Cartan-Muenzner polynomials of degree four”,
   R. Miyaoka, Spanish-Japanese workshop on Differential Geometry (Feb. 18, 2011), Granada, Spain.
2. “Moment maps of the spin action and the Cartan-Muenzner polynomials of degree four”,
   R. Miyaoka, DFG-JSPS Seminar, Lie groups: Geometry and Analysis (Sept. 5 2011), Paderborn, Germany.
3. “Transnormal hypersurfaces, TN systems and TN functions”,
   R. Miyaoka, Geometry and Something, (Nov. 5, 2011) Fukuoka, Japan.

Name **Takashi Shioya**
Department **Mathematics**
Position **Professor**
Research Title **Geometry**

I. Summary of Research

1. Gromov defined a concept of a distance between metric measure spaces which fits to the concentration of measure phenomenon. I proved that the lower bound of Ricci curvature is stable under convergence of metric measure spaces with respect to that distance.
2. As my long-run project, I study the geometric theory of concentration of metric measure spaces based on Gromov's work. In this year, I complete the proof of several statements due to Gromov.

II. Publications

1. K. Kuwae and T. Shioya, A topological splitting theorem for weighted Alexandrov spaces, Tohoku Math. J. (2) 63(2011), no. 1, 59-76.
2. T. Shioya, Collapsing three-manifoldsd with a lower curvature bound, Tohoku Math. J. Centennial Issue (2) 63(2011), no. 4, 471-487.

III. Presentations

1. “Measure concentration and eigenvalues of Laplacian”, T. Shioya, Colloquium Talk (July 11, 2011, Capital Normal University, Beijing, China)
2. “A topological splitting theorem for weighted Alexandrov spaces”, T. Shioya, Geometry Seminar, (July 12, 2011, Captal Normal University, Beijing China)
3. “Concentration, Ricci curvature, and eigenvalues of Laplacian", T. Shioya, Metric Geometry and Applications (July 26-29, 2011, The Purple Palace Nanjing, Nanjing, China)
4. “Survey of geometry of measure concentration", T. Shioya, Sendai Seminar (August 8, 2011, Information of Sciences, Tohoku University, Japan)
5. “Concentration, Ricci curvature, and eigenvalues of Laplacian”, T. Shioya, Geometry and Something (November 3-6, 2011, Seminar House of Fukuoka University, Fukuoka, Japan)

Name **Takayoshi Ogawa**
Department **Mathematics**
Position **Professor**
Research Title **Real and Harmonic Analysis on Nonlinear PDE**

I. Summary of Research

1. Spacialy 1 dimensional Dirac field has a nice integrable structure itself. We consider several system from the Lagrangian including the Dirac Lagrangian density with Chern-Simons Lagrangian density or Higgs density. The corresponding Eluer-Lagrange equation then is the coupled Chern-Simons-Dirac equation. Before stepping into 2 spacial dimensional actual model, we develop some mathematical attempt for 1+1 dimensional Chern-Simons-Dirac (C-S-D in short) system in mathematical point of view. We show that there exists a global large data solution for C-S-D in the scaling critical Banach scale. It is expected that there exists a large data global solution in the scaling critical Hilbert spaces with negative regularity index. However in our observation, the space is not the Hilbert but the Banach so that the inner product structure is not quite required, which is totally new point of view.
2. The 2 dimensional nonlinear Schrödinger-Poisson (NLS-P) system is considered and by the WKB expansion, we derive the coupled compressible Euler-Poisson system from NLS-P system in the energy critical Sobolev space H^1. The main difficulty is the space is not included into the class of essentially bounded function, we need to modify to obtain the uniqueness and WKB limit by sharp estimate for the best possible constant for the inequality of Gagliardo-Nirenberg type. We also derive the convergence rate for WKB analysis.
3. We considered the Schrödinger semigroup with an inverse square singular potential. By a reduction to the lower dimensional problem, we show that the Schrödinger semi-group has L^p type dissipative estimates. The main tool is to use the generalized Young inequality and the Lorentz space.
4. The wellposedness issue on the nonlinear partial differential equation is the main problem in the field of the partial differential equations. We test the nonlinear Schrödinger equation (NLS) with the quadratic nonlinear monomial as the nonlinear coupling to find the threshold functional space for the time local wellposedness holds. It then turns out that the critical situation can be separated by the Besov space in the low space dimensions. We also investigate the similar case may happen to the system of the NLS.

II. Publications

1. T. Ogawa, *The degenerate drift-diffusion system with the Sobolev critical exponent,* Disc. Conti. Dynam. System Ser S., **4** no. 4, (4) (2011), 875-886.
2. T. Nagai, T. Ogawa, *Brezis-Merle inequalities and application to the global existence of the Keller- Segel equations*, Comm. Contemporary Math., **13** no. 5 (2011), 1-18.
3. T. Ogawa, H. Takeda, *Large time behavior of solutions for a system of nonlinear damped wave equations*, J. Differential Equations, **251** (2011), 3090-3113.

III. Presentations

1. Mathematical Models of Biological Phenomena and their Analysis - Dynamics of structure formation in cells and ecological systems-
   "Asymptotic behavior of solution to the degenerate drift-diffusion equation",
   November 23, 2011, Sendai, Japan

Workshop, Seminar, Colloquium

2. 2nd South Osaka Applied Analysis Seminar
   "Dissipative estimate for critical singular potential for the Schrödinger semi-group",
   Osaka, June 20, 2011.
3. Hiroshima Differential Equations seminar
   "Critical Hardy's inequality and some dissipative estimate for critically singular Schrödinger semi-group",
   Hiroshima University, Oct. 7-8, 2011.
4. 1st Muroran Nonlinear Analysis seminar, Tutrial Lecture
   "Degenerate drift-diffusion system for the Sobolev critical case",
   Muroran Inst. Tech., Oct. 28-29, 2011.
5. Workshop "Mathematical Analysis and Differential Equations",
   "Hardy's inequality and L^p -L^q type estimate for critically singular Schrödinger semigroup",
   Yamagata, Nov. 12-14, 2011.
6. Workshop for Partial Differential Equations in North Kyushu
   "WKB approximation for nonlinear Schrödinger -Poisson system",
   Kokura, Kyushu Inst. Tech. Nov. 26, 2011.
7. The third Applied Analysis Symposium in Fukushima
   "Asymptotic analysis for two dimensional partial differential equations",
   Korasse Fukushima, March, 10-11, 2011.

Name	**Kazuhiro Ishige**
Department	**Mathematics**
Position	**Professor**
Research Title	**Asymptotic profiles of the solutions for nonlinear parabolic equations**

I. Summary of Research

1. We considered the Cauchy problem for the heat equation with a radially symmetric potential decaying quadratically at the space infinity, and studied the large time behavior of the solutions. In particular, we studied the decay rate of L^q norm of the solution and the movement of hot spots by using the behavior of the positive harmonic functions at the space infinity.
2. We considered the Cauchy problem for a semilinear heat equation with a non-decaying initial data, and studied the blow-up time and the blow-up set for the solution. In particular, we proved that, if the diffusion coefficient is sufficiently large, then the location of blow-up set is determined by the large time behavior of hot spots for a solution of the heat equation.
3. We considered the Cauchy problem for a doubly nonlinear parabolic equation, and proved that, if there is a nonnegative solution of the Cauchy problem, then the initial trace of the solution is uniquely given as a nonnegative Borel measure satisfying an exponential growth condition. This exponential growth condition is optimal for the existence of nonnegative solutions.

II. Publications

1. “Hot spots for the two dimensional heat equation with a rapidly decaying negative potential”,
   K. Ishige and Y. Kabeya,
   Discrete Contin. Dyn. Syst. Ser. S 4 (No. 4) 833-849, (2011).
2. “On a new kind of convexity for solutions of parabolic problems”,
   K. Ishige and P. Salani,
   Discrete Contin. Dyn. Syst. Ser. S 4 (No. 4) 851-864, (2011).
3. “Blow-up for a semilinear parabolic equation with large diffusion on R^N”,
   Y. Fujishima and K. Ishige,
   J. Differential Equations, 250 (No.5) 2508-2543, (2011).
4. “Initial trace for a doubly nonlinear parabolic equation”,
   K. Ishige and J. Kinnunen,
   J. Evol. Equ., 11 (No.4) 943-957, (2011).

III. Presentations

1. “L^p norms of nonnegative Schrödinger heat semigroup and the large time behavior o f hot spots”,
   K. Ishige, Analyysin lukupiiri, (Jun. 16, Aalto University, Finland).
2. “L^p norms of nonnegative Schrödinger heat semigroup and the large time behavior o f hot spots”,
   K. Ishige, 2nd Italian-Japanese workshop ``Geometric Properties for Parabolic and Elli ptic PDE's'', (Jun. 24, Cortona, Italy).
3. “L^p norms of nonnegative Schrödinger heat semigroup and the large time behavior o f hot spots”,
   K. Ishige, Geometric properties of solutions of nonlinear PDEs and their applications, (Jul. 18, Banff, Canada).
4. “L^p norms of nonnegative Schrödinger heat semigroup and the large time behavior o f hot spots”,
   K. Ishige, Nonlinear Dynamics in Partial Differential Equations (The 4^{th} MSJ-SI), (Se p. 12, Kyusyu University, Japan).

Name **Toshifumi Futamase**
Department **Astronomy**
Position **Professor**
Research Title **General Relativity, Cosmology**

I. Summary of Research

1. Observational Study of Dark matter distribution in the universe by weak lensing, in particular global mass profile and dark matter substructure in galaxy cluster
2. Theoretical Study of the development of new method of weak lensing analysis using higher order moments of shape of background galaxies
3. Theoretical Study on the Non-gaussian fluctuation in micro wave background radiation generated during inflationary period in the early universe

II. Publications

1. "Non-Gaussianity Consistency Relation for Multi-field Inflation ",
   N. S. Sugiyama, E. Komatsu and T. Futamase,
   Physical Review Letters, vol.106 , 251301-1-5, (2011).
2. "Elliptical Weighted HOLICs for Weak Lensing Shear Measurement, part2: PSF correction and application to Abell 370",
   Y. Okura and T. Futamase,
   Astrophysical Journal, in press.

III. Presentations

1. "Weak lensing Study of DM main and sub halos",
   T. Futamase,
   Invited talk, 11th Asian-Pacific Regional IAU Meeting (27^{th} Aug. 2011, Chang Mai, Tailand).
2. "Weak lensing Study of DM sub halos in Coma Cluster",
   T. Futamase,
   Invited talk, The 9^{th} Sino-German Workshop (24-29, April, 2011, Hangzhou, China).
3. "Weak lensing Study of DM sub halos in Coma Cluster",
   T. Futamase,
   Lunch time talk, (26^{th} Jan. 2012, Harvard Smisonian Center for Astrophysics, USA).
4. "A new approach to Non-linear density perturbation",
   T. Futamase,

Invited talk (16th Feb. 2012, ASIAA, Taipei, Taiwan)

5. “WH expansion applied for non-linear evolution of the matter power spectrum”,
   T. Futamase,
   Seminar talk, (23rd Feb. 2012, Hirosaki University)

Name	**Takashi Ichikawa**
Department	**Astronomy**
Position	**Professor**
Research Title	**Study of galaxy evolution at high redshift universe and new instruments for infrared astronomy in Antarctica**

I. Summary of Research

1. We use very deep near-infrared (NIR) imaging data obtained in MOIRCS Deep Survey (MODS) to investigate the evolution of the galaxy stellar mass function back to $z \sim 3$. We present scaling relations between stellar-mass and the size of galaxies at $0.3<z<3$ for half- and 90 percent-light. The logarithmic slope is independent of redshift in a wide mass range, irrespective of galaxy populations (star-forming, quiescent). Provided that optical light in the rest frame traces the stellar mass of galaxies, the universal relation demonstrates that the stellar mass was built up in galaxies over their cosmic histories in a similar manner on average irrelevant to galaxy mass.
2. As a project by National Institute of Polar Research, a new 40cm telescope and an infrared camera have been installed at Syowa station in Antarctica to conduct the studies for exoplanet atmosphere, fossil galaxy remnant around nearby galaxies, and supernova event in luminous infrared galaxies. The telescope and camera are designed to be operated under harsh environment of inland Antarctica. They will be operated from Japan via internet.

II. Publications

1. “Intrinsic Shape of Star-Forming BzK Galaxies at z~2 in GOODS-N”
   Yuma S., Ohta K., Yabe K., Kajisawa M., Ichikawa T., ApJ., 736, 92-105 (2011)
2. “Discovery of an Excess of H Emitters around 4C 23.56 at z = 2:48”
   Tanaka, I. et al., PASJ, 63, 415-435 (2011)
3. “MOIRCS Deep Survey. X. Evolution of Quiescent Galaxies as a Function of Stellar Mass at $0.5 < z < 2.5$ ”
   M. Kajisawa, T. Ichikawa, et al., PASJ, 63, 403-414 (2011)
4. “MOIRCS Deep Survey. IX. Deep Near-Infrared Imaging Data and Source Catalog”
   Kajisawa, M., Ichikawa, T. et al., PASJ, 63, 379-401 (2011)
5. “Cryogenic VPH Grisms for MOIRCS”
   Ebizuka, N. et al., PASJ, 63, 605-612 (2011)
6. “MOIRCS Deep Survey. VII: NIR Morphologies of Star-forming Galaxies at Redshift z~1”
   Konishi, M. et al. PASJ, 63, 363-377 (2011)

III. Presentations

1. “Total to central luminosity ratios of quiescent galaxies in MODS as an indicator of size evolution”
   Mohammad Akhlaghi, Takashi Ichikawa and Masaru Kajisawa in Galaxy Mergers in an Evolving Universe. Oct 23~28 2011, Hualien, Taiwan

Name **Toru Yamada**
Department **Astronomy**
Position **Professor**
Research Title **Galaxy Formation and Evolution**

I. Summary of Research

II. Publications

III. Presentations

Name **Makoto Hattori**
Department **Astronomy**
Position **Associate Professor**
Research Title **Construction of high accuracy components separation scheme for dramatic improvement of detection limit of primordial gravity wave origin cosmic microwave background polarization B-mode signal**

I. Summary of Research

Main goal of my research team is a construction of high accuracy components separation scheme for dramatic improvement of detection limit of primordial gravity wave origin cosmic microwave background polarization B-mode signal. It is known that improvement of accuracies of the separation of emission from Galactic interstellar matters from the cosmic microwave background polarization data is crucial to achieve the aim. We have been trying to improve accuracies of the models of Galactic emission using brand new observational data and theoretical studies. One of the main results of my team in 2011 fiscal year is the achievement of the first release of all sky far infrared maps based on all sky survey data obtained by Japanese Infrared Satellite Akari. My team has taken part in map making tool development team for 6 years as one of main contributers. The map making process has been done by our high performance computer in Sendai. Obtained maps are expected to improve the model of Galactic dust emission which is one of the key foreground components to improve the accuracy of the component separation. We are now working on improving the quality of the maps and developing the component separation scheme taking into account the new results of Galactic dust emission.

II. Publications

1. “Asteroid Catalog Using Akari: AKARI/IRC Mid-Infrared Asteroid Survey”, F. Usui et al., Publications of the Astronomical Society of Japan, Vol.63, pp1117-1138, (2011)

III. Presentations

1. “Science extracted from the cosmic microwave background and the expectation for the PLANCK mission”, M. Hattori, The Physical Society of Japan annual meeting, Sep. 18, 2011, Hirosaki University, Hirosaki, Japan
2. “Numerical modeling of the global Galactic magnetic field structure”, Makoto Hattori, Sho Nakamura, Takahiro Morishima, Astrophysics the radio to the submillimetre Planck and other experiments in temperature and polarization, Feb.13-17, 2012, Area della Ricerca del CNR,

Bologna, Italy

3. “Testing Galactic magnetic field strcutreu model predicted by magnetohydrodynamical numerical simulation using distribution of polarization angle of Galactic synchrotron emission”, Takahiro Morishima, Makoto Hattori, Mami Machida, Ryouji Matsumoto, Sho Nakamura, Astrophysics the radio to the submillimetre Planck and other experiments in temperature and polarization, Feb.13-17, 2012, Area della Ricerca del CNR, Bologna, Italy
4. “AKARI Far-Infrared All Sky Maps”, Y. Doi, et al., Astrophysics the radio to the submillimetre Planck and other experiments in temperature and polarization, Feb.13-17, 2012, Area della Ricerca del CNR, Bologna, Italy
5. “AKARI Far-Infrared All-Sky Survey Maps”, Doi, Y., et. al., The Second AKARI conference: Legacy of AKARI: A Panoramic View of the Dusty Universe, Feb.27, 2012, Ramada Plaza Hotel, Jeju, Korea
6. “AKARI Near-Infrared Spectroscopic Survey for carbon dioxide in Comets”, T. Ootsubo, et al., The Second AKARI conference: Legacy of AKARI: A Panoramic View of the Dusty Universe, Feb.28, 2012, Ramada Plaza Hotel, Jeju, Korea
7. “Construction of global Galactic magnetic field structure model using 3D numerical magneto-hydrodynamic simulations”, The Annual meeting of the Astronomical Society of Japan, March 19-22, 2012, Ryukoku University, Kyoto, Japan
8. “AKARI Far-Infrared All Sky Maps IX (the first release of the all sky maps)”, Y. Doi et al., The Annual meeting of the Astronomical Society of Japan, March 19-22, 2012, Ryukoku University, Kyoto, Japan
9. “All Sky Galactic dust emission map making based on AKARI Far-Infrared All Sky maps II”, T. Ootsubo et al., The Annual meeting of the Astronomical Society of Japan, March 19-22, 2012, Ryukoku University, Kyoto, Japan
10. “Distribution of albedo of main belt asteroid using AKARI asteroid catalog AcuA”, F. Usui et al., The Annual meeting of the Astronomical Society of Japan, March 19-22, 2012, Ryukoku University, Kyoto, Japan
11. “AKARI Far-Infrared All Sky Maps VIII(all sky maps making processes)”, Y. Doi et al., The Annual meeting of the Astronomical Society of Japan, Sep.21, 2011, Kagoshima University, Kagoshima, Japan
12. “AKARI Far-Infrared All Sky Maps VII(absolute calibration using COBE/DIRBE)”, N. Ikeda et al., The Annual meeting of the Astronomical Society of Japan, Sep.22, 2011, Kagoshima University, Kagoshima, Japan
13. “Prediction of statistical size distribution of asteroid using AKARI asteroid catalog AcuA”, F. Usui, et al., The Annual meeting of the Astronomical Society of Japan, Sep.19, 2011,

Kagoshima University, Kagoshima, Japan

14. “All Sky Galactic dust emission map making based on AKARI Far-Infrared All Sky maps”, T. Ootsubo et al., The Annual meeting of the Astronomical Society of Japan, Sep.21, 2012, Kagoshima University, Kagoshima, Japan
15. “Testing Galactic magnetic field strcutreu model predicted by magnetohydrodynamical numerical simulation using WMAP K-band all sky polarization angle distribution”, T. Morishima et al., The Annual meeting of the Astronomical Society of Japan, Sep.19-22, 2012, Kagoshima University, Kagoshima, Japan

Name **Keiichi Noe**
Department **Philosophy**
Position **Professor**
Research Title **1. Science and Technology after the Great East-Japan Earthquake**
2. Narratology of Historiography

I. Summary of Research

1. The Great East-Japan earthquake and the following accident of Fukushima nuclear power plant brought science as well as scientists to "a crisis of trust." In the late 20th century science gradually changed into "trans-science," where cognition of facts and value judgment were inseparable. To recover the decline in trust, it is necessary to introduce "civilian control" of science and technology into the trans-scientific situation and to establish "intergenerational ethics" for the future generation.
2. Some criticisms are delivered on my "Narratoligy of History," especially in Tadami Chizuka's *An Introduction to Historiography*. I answer his criticism point by point and expand my argument. First, historical facts do not subsist without concepts and frame of reference, i.e. narrative. Second, his interpretation of Popper's "falsification" is based on fundamental misunderstanding, and the procedure of falsification is still valid in the "Narratorogy of History."

II. Publications

1. "Disaster and the Risk-Society" (in Japanese), K. Noe, GAKUTOU, Vol.108 No.2, pp.26-29, (2011)
2. "Rehabilitation of 'Quality Space'" (in Japanese), K. Noe, Journal of Japan Society for Office Studies, Vol.3 No.2, pp.4-6, (2011)
3. "From Seeing to Acting" (in Japanese), K. Noe, Tetsugaku-Zasshi, Vol.126 No.798, pp.45-63, (2011)
4. "In Defense of "Narratology of History": A response to Tadami Chizuka's *Introduction to Historiography*" (in Japanese), K. Noe, to appear in RISSHO University Research Report.
5. "Hermeneutic Problems in the Philosophy of Science", K. Noe, to appear in Nagoya University GCOE Program HERSETEC International Conference Series No.12.

III. Presentations

1. “Why Education of Philosophy is necessary? ”, K. Noe, the Philosophical Association of Japan 2011 Annual Meeting (May 14-15, 2011, Tokyo University, Tokyo, Japan)
2. “EBM and NBM in Palliative Medicine”, K. Noe, The 16th Congress of the Japanese Society for Palliative Medicine (July 29-30, 2011, , ROYTON Sapporo, Japan)
3. “Science and Technology after the Great East-Japan Disaster”, K. Noe, Japan Society of Civil Engineers Talk Saloon (September 12, 2011, Doboku-Gakkai, Tokyo, Japan)
4. “Science and Education after the Great East-Japan Disaster”, K. Noe, IDE University Seminar (November 18, 2011, Sendai Garden Palace, Sendai, Japan)
5. “Kunio Yanagita living in the contemporary world”, TOHOKU BUNKA Lecture Series (November 19, 2011, Tohoku University, Sendai, Japan)
6. “Hermeneutic Problems in the Philosophy of Science”, K. Noe, Nagoya University GCOE Program HERSETEC International Conference (December 9, 2011, Nagoya University, Nagoya, Japan)
7. “Responsibility for the future generation”, K. Noe, University Education Reformation Forum in TOKAI 2012 (March 3, 2012, Nagoya University, Nagoya, Japan)
8. “Narrative and Caring after the Great Disaster”, K. Noe and T. Kawamoto, International Conference: Disaster and the Creation of Value System (March 9-10, Tohoku University, Sendai, Japan)

Name **Kiyotaka Naoe**
Department **Philosophy**
Position **Associate Professor**
Research Title **Study of Philosophy and Ethics of Technology**

I. Summary of Research

1. I investigate Japanese philosophy of technology from a contemporary perspective. Theories of technological mediation developed by some pre- and postwar Japanese philosophers (ex. K.Miki, H.Saegusa) gave a comprehensive understanding to the technological process as a whole. Through a critical examination, I argue that these theories can contribute to mediate subdivisions of this field (philosophy of design, philosophy of engineering science, ontology of artifacts etc.) and thus to reconstruct an integrated view of technology.
2. Brain-machine interface is a direct communication pathway between a neural system and an external device (computer system etc.). This technology can be used, for example, for neuroprosthesis that aims to restore human functions, but there are debates about its ethical implications, especially about human enhancement. Based on philosophical considerations about this new technology, I evaluate the main arguments against the human enhancement and propose a common platform for further ethical discussions.

II. Publications

1. “Karl Löwoth revisited”, Kiyotaka Naoe,
   Annual review of the Tohoku Philosophical Associatio(Tohoku-Tetsugakukai-Nenpo), No.27, pp.63-77, 2011.
2. “From Engineering Ethics to the Ethics of Technology ”, Kiyotaka Naoe,
   Engineering Ethics and the Society(Gijutsu rinri to Shakai), vo.6, pp.105-115, 2011.
3. “Artifdacts and techonological Knowledge", Kiyotaka Naoe, *Shisaku(Meditations)*, vol.44,pp.1-30, 2011.
4. “Philosophy of Science and Philosophy of Technology today”, Kiyotaka Naoe,
   Kunitsugu Kosaka, Hitoshi Hongo(ed), *Contemporary Philosophy*, Minerva Shobo, 2012(in printing).

III. Presentations

1. “What is the Functions of Artifacts? ”, Kiyotaka Naoe,
   3rd Annual Meeting of the Japanese Association for the Contemporary and Applied Philosophy, April 24, Chiba University, Chiba, Japan.

2. “How to Discuss the Risk of the Atomic Power Plants”, Kiyotaka Naoe,
   Symposium “How can Sciences deal with the problem of the diffused radioactive materials” (The Japan Society of Applied Physics Tohoku Chapter), September 23, AER Hall Sendai, Sendai, Japan.
3. “Functions of Artifacts”, Kiyotaka Naoe,
   Special Meeting of the Japanese Association for the Contemporary and Applied Philosophy, September 24, Kyoto University, Kyoto, Japan.
4. “How can Philosopher tackle the big Disaster - Giant Earthquake, Tsunami, and the Nuclear Accident”, Kiyotaka Naoe,
   Symposium of the Japanese Society for Ethics, September 30, Toyama University, Toyama, Japan.
5. “Cummunication on Nuclear Energy after Fukushima”, Kiyotaka Naoe,
   Workshop on the Discourse Ethics and Science, October 10, Tohoku University, Sendai, Japan.
6. “Engineering Judgment and Exterpise”, Mariko Nihei, Kiyotaka Naoe,
   10th Annual Meeting of the Japanese Society for Science and Technology Studies, December 4, 2011, Kyoto University, Kyoto, Japan
7. “Philosophy of Design” Kiyotaka Naoe,
   Workshop on Ecological Psychology and Technology, December 26, 2011, Rissho University, Tokyo, Japan
8. “Philosophy of Technology : Historical Perspectives”, Kiyotaka Naoe,
   Workshop on the Philosophy of Technology, February 21, Tohoku University, Sendai, Japan.
9. “Nuclear Accident and the Transformation of Value System”, Kiyotaka Naoe,
   International Conference:Disaster and the Creation of Value System, March 10, 2012, Tohoku University, Sendai, Japan