

4.2. GCOE Assistant Professor and Young Scientist Initiative B

The GCOE employed 63 assistant professors in 2008-2012 fiscal year, and supported 52 assistant professors as "Young Scientist Initiative B" of giving the encouragement research expense. They did 135 publications, and 274 presentations at conferences/meetings in Japan and abroad.

In 2012 fiscal year, 12 GCOE assistant professors were employed, and did 29 publications, and 53 presentations at conferences/meetings in Japan and abroad. Their names and research titles are as listed below. Then, their research reports are the following.

1. **Takeshi Koike** (Nuclear physics)
"Gamma-ray spectroscopy at J-PARC with Hyperball-J"
2. **Mikito Tanaka** (Astrophysics)
 1. "Understanding structure and formation of galaxies based on Galactic Archaeological method"
 2. "Development of PBL-type liberal arts educations based on Astronomical research activity"
3. **Shumpei Masuda** (Condensed matter physics)
"Ideal manipulation of quantum states with Fast-forward scaling method"
4. **Tsuguhiko Asakawa** (Particle physics)
"Research on the structure of spacetime in string theory from generalized geometry"
5. **Satoshi Heguri** (Condensed matter physics)
"Superconductivity in aromatic hydrocarbon compounds"
6. **Joji Nasu** (Condensed matter physics)
"Novel quantum state and spin-orbital dynamics attributed to dynamical Jahn-Teller effect"
7. **Daisuke Nitta** (Astrophysics)
"Constraints on primordial non-gaussianity from cosmic micro wave background and large scale structure"
8. **Nomura Daisuke** (Particle Physics)
"Probing new physics from electroweak precision measurements and results at LHC experiments"

9. **Naoto Yokoi** (Particle Physics)

"Study on strong coupling dynamics of supersymmetric gauge field theories using strong-weak coupling duality"

10. **Toshiaki Omori** (Mathematics)

"On the existence of harmonic maps via exponentially harmonic maps"

11. **Yuken Miyasaka** (Mathematics)

"Approach to arithmetic problem via p-adic Sato theory"

12. **Kazushige Nakagawa** (Mathematics)

"New developments of qualitative property for fully nonlinear partial differential equations of L_p -viscosity solutions"

No.1

Name	Takashi Koike
Department	Physics
Position	Assistant Professor
Research Title	Gamma-ray spectroscopy at J-PARC with Hyperball-J

I. Summary of Research

1. Completion of the Ge array, Hyperball-J and SKSMinus magnetic spectrometer system at the K1.8 beam line at J-PARC.
2. Commissioning of the SKSMinus system and Hyperball-J at the K1.8 beam line from March 9-26.
3. A test experiment of Hyperball-J Ge detector units at the K1.1BR beam line at J-PARC in June-July, 2012.

II. Publications

1. K. Shirotori *et al.*, "Search for the Θ^+ Pentaquark via the $\pi^+p \rightarrow K^+X$ Reaction at 1.92 GeV/c" Phys. Rev. Lett. **109**, 132002 (2012)
2. Tamura, H. , Ukai, M., Yamamoto, T.O., Koike, T. "Study of Λ hypernuclei using hadron beams and γ -ray spectroscopy at J-PARC" Nuclear Physics A **881**, 310 (2012)
3. J. F. Smith *et al.*, " γ -ray spectroscopy of neutron-deficient ^{123}Ce " Phys. Rev. C **86**, 034303 (2012)
4. D. Sohler *et al.*, "High-spin structure of ^{104}Pd " Phys. Rev. C **85**, 044303 (2012)

III. Presentations

1. T.Koike, "gamma-ray spectroscopy of *sd*-shell nuclei at J-PARC", The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-5, 2013, Tohoku University, Sendai, Japan)
2. T.Koike, "Lambda particle as a probe of nuclear structure", VIII TOURS SYMPOSIUM ON NUCLEAR PHYSICS AND ASTROPHYSICS, Lenzkirch-Saig, Germany, September 2 - 7, (2012)
3. T.Koike, "Hypernuclear γ -ray spectroscopy experiments at J-PARC", International Workshop on Strangeness Nuclear Physics, Neyagawa, Osaka, August 27– 29 , (2012)

No.2**Name** Mikito Tanaka**Department** Astronomy**Position** Assistant Professor

Research Title 1. Understanding structure and formation of galaxies based on Galactic Archaeological method

2. Development of PBL-type liberal arts educations based on Astronomical research activity

I. Summary of Research

1. This year, our 3 Subaru proposals were accepted. In the two of them, we have already conducted the observations of nearby isolated-galaxy, M31's halo and Galactic globular clusters with complicated stellar populations under the good sky conditions. We have originally developed a pipeline for automatically reducing the huge raw data of M31's halo, based on Python and PyRAF. Furthermore, we have confirmed high availability of a method that we can easily separate M31's RGB stars from heavy contaminations of Milky Way's dwarf stars using the narrow-band filter, NB515.
2. In KISO-seminar for 1 semester and Current Topics for 2 semester, we have practiced the two PBL-type lectures we had developed last year. Through the classes, we developed some important social skills of students as well as astronomical and scientific skills. Especially, our KISO-seminar was highly evaluated from students and got extremely high score (4.8/5.0) in all the liberal arts classes of Tohoku University.

II. Publications

1. "The Educational Effects of Project-Based Learning based on Astronomical Research Activities in Baccalaureate Education", Tanaka, M., CAHE Journal of Higher Education 2013, Center for the Advancement of Higher Education (Tohoku Univ.), Vol.8, 14pp (2013)
2. "Global Properties of M31's Stellar Halo from the SPLASH Survey: I. Surface Brightness Profile", Gilbert, K. M., Guhathakurta, P., Beaton, R. L., Bullock, J., Geha, M. C., Kalirai, J. S., Kirby, E. N., Majewski, S. R., Ostheimer, J. C., Patterson, R. J., Tollerud, E. J., Tanaka, M., Chiba, M., The Astrophysical Journal, 760, 76(21pp), 2012
3. "A spectroscopic survey of Andromeda's Western Shelf", Fardal, M. A., Guhathakurta, P., Gilbert, K. M., Tollerud, E. J., Kalirai, J. S., Tanaka, M., Beaton, R., Chiba, M., Komiyama, Y., Iye, M., , MNRAS, 423, 3134-3147, 2012
4. "Structure and Population of the NGC 55 Stellar Halo from a Subaru/Suprime-Cam Survey", Tanaka, M., Chiba, M., Komiyama, Y., Guhathakurta, P., & Kalirai, J. S., , Galactic Archaeology: Near-Field Cosmology and the Formation of the Milky Way, 458, 279-282, 2012

III. Presentations

1. "Practice and Evaluation of an Active Learning Lecture for covering Astronomical education and Career education", Tanaka, M., ASJ spring annual meeting, 03/2013, Saitama Univ., Saitama, Japan
2. "The Effectivity of the NB515 filter for the Andromeda Galactic Halo Survey using Subaru/Hyper Suprime-Cam", Tanaka, M., ASJ spring annual meeting, 03/2013, Saitama Univ., Saitama, Japan
3. "The Design Study of the Andromeda Galactic Halo Survey based on Subaru/Hyper Suprime-Cam and NB515 Narrowband Filter", Tanaka, M., The 5th GCOE International Symposium, 03/2013, Tohoku Univ., Sendai, Japan
4. "The Effectivity of the NB515 filter for the Subaru Andromeda Galaxy Halo Survey", Tanaka, M., Korea-Japan Mini-Workshop on the Local Universe, 02/2013, Seoul National Univ., Seoul, Korea
5. "Observational Study of the Andromeda Galactic Halo using Subaru/Hyper Suprime-Cam and the NB515 filter", Tanaka, M., Subaru/HSC Science meeting, 09/2012, NAOJ, Tokyo, Japan
6. "Outreach Activity as Career education for University Students in Science", Tanaka, M., JSET annual meeting, 09/2012, Nagasaki Univ., Nagasaki, Japan

No.3

Name	Shumpei Masuda
Department	Physics
Position	Assistant Professor
Research Title	Ideal manipulation of quantum states with Fast-forward scaling method

I. Summary of Research

1. We studied the rapid loading of BECs into an optical lattice without energy excitation by using the fast-forward scaling theory. We have shown that the simple driving potential which would be experimentally accessible can load BEC in the optical potential without disturbance.
2. We showed a method to protect quantum states from the disturbance due to the random potential by successive rapid manipulations of the quantum states. The quantum states are kept undisturbed for a longer time than the case of the simple trapping with a stationary potential. The effective potential, which the quantum states feel, becomes uniform when the velocity of the transport is sufficiently large. It was also shown that the alternating transport of a Bose-Einstein condensate can protect it from the disturbance.
3. We investigated the Landau levels on the surface of Bi₂Se₃ and Sb₂Te₃ with the magnetic field. We related the energy dispersion of the bulk and the surface by using the effective lattice model characterizing the low-energy long-wavelength properties of the bulk and surfaces. The effective g-factor of the surface was derived from the information of the energy dispersion around the Γ point of the bulk.

4. We studied classical and quantum dynamics of two spinless fermions confined in a quantum wire with repulsive or attractive Coulomb interaction. We introduced a modified maximum Lyapunov exponent, which is shown to be suitable measure of chaotic irregularity for the present classical system. We showed that tendency of the energy dependence of the Brody parameter, which characterizes the energy level statistics in the quantum system, is consistent with that of the modified maximum Lyapunov exponent.

II. Publications

1. "Acceleration of adiabatic transport of interacting particles and rapid manipulations of dilute Bose gas in ground state", S. Masuda, Phys. Rev. A, 86 063624 (2012)
2. "Interference effects of helical current: Geometry-dependent spin polarization of transmitted electrons", S. Masuda and Y. Kuramoto, Phys. Rev. B, 85, 195327 (2012)
3. "Protection of quantum states from disturbance due to random potential by successive translation", S. Masuda, arXiv:1301.7135 (2013).
4. "Quantum and classical chaos of a two-electron system in a quantum wire", S. Masuda, S. Sawada and Y. Shimizu, arXiv: 1209.3287 (2013).

III. Presentations

1. "Fast-forward theory in many body systems and decrease of effects of noise on quantum states by rapid manipulation", S. Masuda and K. Nakamura, International conference Shortcuts to Adiabaticity (July16-20, 2012, QUINST UPV/EHU, Bilbao, Spain)
2. "Energy spectrum and effective g-factor of Bi₂Se₃ topological insulator under magnetic field", S. Masuda and Y. Kuramoto, Japan Physical Society 2012 Autumn Meeting (September 16-19, 2012, Yokohama University, Yokohama, Japan)
3. "Reduction of effect of noise by rapid manipulation with fast-forward scaling theory", S. Masuda, QIT27 (November 27-28, 2012, Keio University, Tokyo, Japan)
4. "Rapid control of Bose-Einstein condensates with less disturbance", S. Masuda, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.4

Name	Tsuguhiko Asakawa
Department	Physics
Position	Assistant Professor
Research Title	Research on the structure of spacetime in string theory from generalized geometry

I. Summary of Research

1. D-branes in generalized geometry and the DBI action

Generalized geometry is a new area of mathematics and is an extension of ordinary differential geometry, by treating vector fields and 1-forms in an equal footing. In this geometry, a metric field and a B-field appearing in superstring theory are combined into a single generalized metric, and the T-duality is well described in this setting. Thus it is a useful tool to understand the structure of superstring theory. However, D-branes have not yet been studied well in this context.

In this work, we have described D-branes in generalized geometry. We introduced a D-brane as a Dirac structure, which treats gauge fields and scalar fields on a D-brane in an equal footing. This raises a new picture for a D-brane as a leaf of a foliation in spacetime. When there is a generalized metric in spacetime, we showed that the generalized metric seen by a D-brane coincides with the formula for the T-duality rule.

As an application of this new viewpoint, we then studied the Dirac-Born-Infeld (DBI) action, which is known as the effective theory on a D-brane. For vanishing gauge fields, the Nambu-Goto action for scalar fields is known as a unique action determined by the non-linearly realized Lorentz symmetry. Here the scalar fields are Nambu-Golodstone (NG) modes for spontaneously broken translational symmetry in spacetime. From our treatment, scalar and gauge fields play the similar role. Thus, we argued that gauge fields are NG modes for spontaneously broken B-field gauge transformation and the DBI action is a unique action for this broken symmetry. It can be said that the DBI action is the generalized Nambu-Goto action. (published)

2. Angles in Fuzzy Disc and Angular Noncommutative Solitons

The fuzzy disc is a disc-shaped region in a noncommutative plane, and is a fuzzy approximation of a commutative disc. We studied this fuzzy disc by introducing a new concept of angles. We defined an angle coordinate in a fuzzy disc by using the phase operator and phase states developed in quantum optics. This enables us to describe the function algebra on a fuzzy disc in the standard way in terms of operators and their commutation relations, as oppose to the former description of a fuzzy disc which relies on the noncommutative plane.

We then studied properties of angular projection operators. A similar construction for a fuzzy annulus is also given. As an application, we constructed fan-shaped soliton solutions of a scalar field theory on a fuzzy disc, which corresponds to a fan-shaped D-brane. We also applied this concept to the theory of noncommutative gravity that we proposed in the past. In addition, possible connections to black hole microstates, holography and an experimental test of noncommutativity by laser physics were discussed. (work submitted to arXiv)

II. Publications

1. "Boundary state analysis on the equivalence of T-duality and Nahm transformation in superstring

theory", T. Asakawa, U. Carow-Watamura, Y. Teshima, S. Watamura, Progress of Theoretical Physics, Vol.127, No.4, 665-687, (2012).

2. "D-branes in Generalized Geometry and Dirac-Born-Infeld Action", T. Asakawa, S. Sasa, S. Watamura, Journal of High Energy Physics, Vol. 1210, 064, (2012).

III. Presentations

1. "D-branes in generalized geometry", T. Asakawa, Discretization approaches to the dynamics of space-time and fields (August 30-September 2, 2012, RIKEN Nishina Center, Wako, Saitama, Japan).
2. "D-branes in generalized geometry", T. Asakawa, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.5

Name	Satoshi Heguri
Department	Physics
Position	Assistant Professor
Research Title	Superconductivity in aromatic hydrocarbon compounds

I. Summary of Research

1. We developed an innovative synthesis method for hydrocarbon compounds in order to prepare high quality samples.
It was difficult to obtain high homogeneous and crystallinity samples using conventional annealing technique due to the low melting point of hydrocarbon materials. The newly developed method took account of peculiar properties of hydrocarbon materials. Consequently, we succeed the accurate phase control in hydrocarbon compounds.
2. We successfully synthesized alkali metal intercalated polyacenes, anthracene, tetracene, and pentacene using an improved solid-state grinding and diffusion methodology. The Mott electronic state we strongly supported for K_1 Anthracene by both magnetic and optical repulsion U ($\sim 1\text{eV}$) and band width W ($\sim 0.6\text{eV}$) are considered in the itinerant band limit. On the other hand, divalent electronic states were more favored for doped phases in the case of tetracene and pentacene. Based on the present results, in order to understand the reported metallic and superconducting states of alkaline metal intercalated picene, phenanthrene and coronene, some other factors such as degenerate levels and armchair configurations should properly taken into account.

II. Publications

1. "Suppression of backward scattering of Dirac fermions in iron pnictides $\text{Ba}(\text{Fe}_{1-x}\text{Ru}_x\text{As})_2$ ", Yoichi

- Tanabe, Kuong Kim Hyunh, Takahiro Urata, **Satoshi Heguri**, Gang Mu, Jingtao Xu, Ryo Nouchi, Katsumi Tanigaki, Physical Review B 86, 094510 (2012).
2. "Quantitative relation between structure and thermal conductivity in type-I clathrates $X_8\text{Ga}_{16}\text{Ge}_{30}$ ($X = \text{Sr}, \text{Ba}$) based on electrostatic-potential analysis", Akihiko Fujiwara, Kunihisa Sugimoto, Che-Hsiu Shih, Hiroshi Tanaka, Jung Tang, Yoichi Tanabe, Jingtao Xu, **Satoshi Heguri**, Katsumi Tanigaki, Masaki Takata, Physical Review B. 85 (2012) 144305.

III. Presentations

[INVITED TALKS]

1. **Satoshi Heguri** (invited), Katsumi Tanigaki, "Anharmonic vibration of guest atoms induced anomalous physical properties in type-1 clathrate", Joint seminar in Department of Physics, (January 24, 2012, University of Hyogo, Kamigohri, Akoh, Japan)
2. **Satoshi Heguri** (invited), Jingtao Xu, Yoichi Tanabe, Hidekazu Shimotani, Katsumi Tanigaki, "Anharmonicity of phonons created in materials having nano spaces: Synthesis, physical properties and applications to thermoelectrics", International Conference on Emerging Advanced Nanomaterials-2012, Australia, Queensland, November 23, 2012.

[INTERNATIONAL]

3. "Quantum critical behavior in type-1 clathrate $\text{Eu}_x\text{Sr}_{8-x}\text{Ga}_{16}\text{Ge}_{30}$ ", **S. Heguri**, Y. Tanabe, J. Xu, G. Mu, H. Shimotani, K. Tanigaki, International Conference on Emerging Advanced Nanomaterials, October 22-25, Queensland, Australia.
4. "Static Eu atoms endohedral type-1 clathrate", **S. Heguri**, Y. Tanabe, J. Xu, G. Mu, H. Shimotani, K. Tanigaki, International Symposium on Molecular Materials and Devices 2012, September 23 to 29, Durham University, Durham, UK.

[DOMESTIC]

5. "Magnetic properties of aromatic hydrocarbon compounds", **S. Heguri**, P. Quynh, Y. Tanabe, H. Shimotani, K. Tanigaki, Japan Physical Society 2013 Spring Meeting, March 26-29, 2013, Hiroshima University, Hiroshima, Japan.
6. "Physical properties of alkali or alkaline earth metal doped fused ring compounds", **S. Heguri**, P. Quynh, Y. Tanabe, H. Shimotani, K. Tanigaki, metal Complex compounds Annual Meeting 2012, February 4-6, 2012, Tohoku University, Sendai, Japan.
7. "Ground state in polycyclic aromatic hydrocarbon compounds", **S. Heguri**, P. Quynh, Y. Tanabe, T. Urata, H. Shimotani, K. Tanigaki, The Carbon Society of Japan 2012 General Meeting, November 28-30, 2013, TAiGO, Nagano, Japan.
8. "Magnetic Properties of aromatic hydrocarbon compounds", S. Heguri, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku

University, Sendai, Japan)

No.6

Name	Joji Nasu
Department	Physics
Position	Assistant Professor
Research Title	Novel quantum state and spin-orbital dynamics attributed to dynamical Jahn-Teller effect

I. Summary of Research

1. Superconductivity and polar charge fluctuation are studied in an organic conductor with the dimer-molecule degree of freedom. The extended Hubbard models, where the intra-dimer electronic structure and the inter-dimer Coulomb interactions are taken into account, are analyzed by the random-phase approximation and the fluctuation-exchange approximation. Superconductivity appears in a vicinity of the charge-density wave (CDW) phase where the electronic charge distributions are polarized inside of dimers. The extended s-wave type pairing is favored and its competitive relations with the superconductivity due to the spin fluctuation depend on the triangular lattice geometry. Comparison between two superconductivities realized near the polar and non-polar CDW phases are also examined.
2. Dynamical Jahn-Teller (DJT) effect in spin-orbital coupled system on a honeycomb lattice is examined, motivated from recently observed spin-liquid behavior in $\text{Ba}_3\text{CuSb}_2\text{O}_9$. Effective vibronic Hamiltonian, where the superexchange interaction and the DJT effect are taken into account, is derived. We find that the DJT effect induces a spin-orbital resonant state where local spin-singlet states and parallel orbital configurations are entangled with each other. This spin-orbital resonant state is realized in between an orbital ordered state, where spin-singlet pairs are localized, and an antiferromagnetic ordered state. Based on the theoretical results, a possible scenario for $\text{Ba}_3\text{CuSb}_2\text{O}_9$ is proposed.

II. Publications

1. "Ordering and excitation in orbital compass model on a checkerboard lattice", J. Nasu, S. Todo, and S. Ishihara, Physical Review B, 85, 2012, (2012)
2. "Electron correlation and dynamical Jahn-Teller effect in orbitally degenerate system", J. Nasu, and S. Ishihara. accepted to J. Korean Phys. Soc.
3. "Polar Charge Fluctuation and Superconductivity in Organic Conductor", A. Sekine, J. Nasu, and S. Ishihara, accepted to Physical Review B.
4. "Dynamical Jahn-Teller Effect in Spin-Orbital Coupled System", J. Nasu, and S. Ishihara,

arXiv:1209.0239.

III. Presentations

1. "Dynamical Jahn-Teller effect in a spin-orbital coupled system: implications to magnetic and orbital state in Ba₃CuSb₂O₉", J. Nasu and S. Ishihara, Highly Frustrated Magnetism 2012 (June 4-6, 2012, McMaster University, Hamilton, Canada)
2. "Electron Correlation and Dynamical Jahn-Teller Effect in Orbitally Degenerate System", J. Nasu and S. Ishihara, The 19th International Conference on Magnetism 2012 (July 11-17, 2012, Busan, Korea)
3. "Dynamical Jahn-Teller Effect in Spin-Orbital Coupled System II", J. Nasu and S. Ishihara, Japan Physical Society 2012 Autumn Meeting (September 16-19, 2012, Yokohama National University, Yokohama, Japan)
4. "Quantum entanglement between spin and orbital induced by Dynamical Jahn-Teller Effect", J. Nasu and S. Ishihara, Physics of Quantum Spin System (November 12-14, 2012, Yukawa Institute for Theoretical Physics, Kyoto, Japan)
5. "Orbital Dynamics coupled with Jahn-Teller phonons in Strongly Correlated Electron System", J. Nasu, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)
6. "Theory of Orbital-Lattice Dynamics in strongly correlated electron system", J. Nasu and S. Ishihara, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Japan)

No.7

Name	Daisuke Nitta
Department	Astronomy
Position	Assistant Professor
Research Title	Constraints on primordial non-gaussianity from cosmic micro wave background and large scale structure

I. Summary of Research

1. We have studied the Non-gaussianities of the galaxy distribution. These Non-gaussianities are generated by some phenomenon such as inflation (primordial Non-gaussianity), gravitational evolution, redshift distortion and bias. To extract the primordial non-gaussianity, we have induced cross-skewness. We find that this variable suppress the non-linear effect except the primordial one. The fact shows this method is more efficient than usual skewness method.
2. We have studied the analytic estimates of structures of multi black hole shadows (eyebrow-like structure and deformation) using the static multi-black hole solution (Majumdar-Papapetrou solution). We find that the width of the eyebrow is related with the distance

between the black holes and that the shadows are deformed into ellipses due to the presence of the second black holes. These results are helpful to understand qualitatively the features of the shadows of colliding black holes.

II. Publications

1. "Shadows of Multi Black Holes: Analytic Exploration", A. Yumoto, D. Nitta, T. Chiba, N. Sugiyama, Physical Review D, 86, 103001, (2012)

III. Presentations

1. "Shadows of Multi Black Holes", D. Nitta, 49th Winter School of Theoretical Physics "Cosmology and non-equilibrium statical mechanics", (February 11-16, Landek-Zdroj, Poland)
2. "Shadows of Multi Black Holes", D. Nitta, The Astronomical Society of Japan 2012 Spring Meeting (March 19-22, 2012, Saitama University, Saitama, Saitama, Japan)
3. "Constraints on Primordial Non-gaussianity by Using Skewness of Galaxy distribution in Redshift Space", D. Nitta, The Astronomical Society of Japan 2012 Spring Meeting (March 19-22, 2012, Saitama University, Saitama, Saitama, Japan)
4. "Cross skewness of redshifted galaxy distribution", D. Nitta, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.8

Name	Daisuke Nomura
Department	Physics
Position	Assistant Professor
Research Title	Probing new physics from electroweak precision measurements and results at LHC experiments

I. Summary of Research

1. This year I mainly conducted researches in electroweak precision physics. In particular, in the paper listed below, my collaborator Dr. T. Teubner and I computed hadronic contributions to the anomalous magnetic moment of the electron (called the electron $g-2$) and to the hyperfine splitting of muonium. These quantities are measured very precisely, and at the same time can be calculated very precisely in the framework of the Standard Model of particle physics. Therefore they are good probes of new physics beyond the Standard Model. In the paper, we have reduced the uncertainty of the leading-order hadronic contribution to the electron $g-2$ by about 40%, and that to the hyperfine splitting of the muonium by a factor of 2. I also gave talks about these results at some of the

workshops listed below.

II. Publications

1. "Hadronic contributions to the anomalous magnetic moment of the electron and the hyperfine splitting of muonium", D. Nomura and T. Teubner, Nuclear Physics, **B867**, 236, (2013).

III. Presentations

1. "Updates on Muon g-2", D. Nomura, seminar at Nagoya University (May 22, 2012, Nagoya, Japan)
2. "Theoretical Updates on Muon g-2", D. Nomura, at "The 5th collaboration meeting on muon g-2/EDM experiments at J-PARC" (June 28-30, 2012, KEK, Tsukuba, Japan)
3. "MSSM confronts precision electroweak data and muon g-2", D. Nomura, workshop "New developments in flavor physics, " (July 6-8, 2012, Yoshino, Nara, Japan)
4. "Re-evaluating hadronic contribution to muonium ground-state hyperfine splitting", D. Nomura and T. Teubner, Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)
5. "Status of hadronic contributions to lepton g-2", D. Nomura, at "The 12th International Workshop on Tau Lepton Physics (Tau2012)," (September 17-21, 2012, Nagoya, Japan).
6. "Status of Muon g-2 Calculations", D. Nomura, at "The 6th collaboration meeting on muon g-2/EDM experiments at J-PARC" (November 1-3, 2012, KEK, Tsukuba, Japan)
7. "Status of hadronic contributions to lepton g-2", D. Nomura, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.9

Name	Naoto Yokoi
Department	Physics
Position	Assistant Professor
Research Title	Study on strong coupling dynamics of supersymmetric gauge field theories using strong-weak coupling duality

I. Summary of Research

1. We studied a possibility of electric-magnetic dual description of quantum chromodynamics (QCD). In particular, we proposed a possible magnetic-dual theory for QCD based on the Seiberg-duality in softly-broken supersymmetric gauge theory, and constructed a solitonic vortex solution in our dual theory, corresponding to the confining color-flux in the original QCD.
2. We studied the asymptotic symmetries of various black hole solutions from the perspective of the

AdS/CFT correspondence. Concretely, we investigated the asymptotic supersymmetry in the near horizon geometry of rotating supersymmetric black holes in five-dimensional supergravity, and also studied the asymptotic symmetry of rotating black holes with electric charges in three-dimensional space-time.

II. Publications

1. "Making confining strings out of mesons", A. Ryuichiro Kitano, B. Mitsutoshi Nakamura, and C. Naoto Yokoi, Physical Review D, Vol. 86, Issue 1, pp.014510.1-014510.10 (2012).
2. "Near Horizon Superconformal Symmetry of Rotating BPS Black Holes in Five Dimensions ", A. Masayoshi Nakamura and B. Naoto Yokoi, Progress of Theoretical Physics, Vol. 128, No. 2, pp.251-272, (2012).

III. Presentations

1. "Making confining strings out of mesons", A. Naoto Yokoi, YITP Workshop "Field Theory and String Theory" (July 23-27, 2012, Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan).
2. "Making confining string out of mesons", A. Ryuichiro Kitano, B. Mitsutoshi Nakamura and C. Naoto Yokoi, Japan Physical Society 2012 Autumn Meeting, (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan).
3. "Towards a magnetic dual of QCD", A. Naoto Yokoi, International Workshop on Theoretical Particle Physics 2012 at Asuka (September 24-26, 2012, Iwaido-so, Asuka, Nara, Japan).

No.10

Name	Toshiaki Omori
Department	Mathematics
Position	Assistant Professor
Research Title	On the existence of harmonic maps via exponentially harmonic maps

I. Summary of Research

1. I submitted a paper on an existence theorem for harmonic maps from closed surfaces via ε -exponentially harmonic maps. (This article appeared in International Journal of Mathematics)
2. I studied an evolution equation of ε -exponentially harmonic maps. It was confirmed that this equation always has a global smooth solution without any assumption on the domain and the target provided $\varepsilon > 0$ is sufficiently small. Such a solution is expected to always converge to an ε -exponentially harmonic map as time goes infinity. Also, such a solution is expected to, in some suitable cases, converge to a harmonic map as time goes to infinity in the same breath as ε goes to zero. These are future subjects.

II. Publications

1. "On Sacks-Uhlenbeck's existence theorem for harmonic maps via exponentially harmonic maps", T. Omori, Internat. J. Math., 23, 6pp, (2012)

III. Presentations

1. "On the existence of harmonic maps via exponentially harmonic maps", T. Omori, The Fourth Geometry Meeting --- dedicated to the centenary of A. D. Alexandrov --- (August 20-24, 2012, The Euler International Mathematical Institute and The Steklov Institute, St. Petersburg, Russia)
2. "On symplectic hypersurfaces of low degree in a projective space", T. Omori, Geometry Seminar (January 15, 2013, Tohoku University, Sendai, Japan)
3. "On the existence of harmonic maps via exponentially harmonic maps", T. Omori, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy" (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.11

Name	Yuken Miyasaka
Department	Mathematics
Position	Assistant Professor
Research Title	Approach to arithmetic problem via p-adic Sato theory

I. Summary of Research

1. We study torsion points on hyperelliptic Jacobians via Anderson's p-adic soliton theory. We show that torsion points of certain orders are not on a theta divisor in the Jacobian variety of a hyperelliptic curve given by the equation $y^2 = x^{2g+1} + x$ with $g \geq 2$. The proof employs a method of Anderson who proved an analogous result for a cyclic quotient of a Fermat curve of prime degree.
2. Honda proved that for an elliptic curve E over \mathbb{Q} its formal group is strongly isomorphic over \mathbb{Z} to the formal group obtained from the L-series attached to the l-adic Galois representations on E . We generalize Honda's theorem to abelian varieties over \mathbb{Q} with complex multiplication. As an application, we give a way of calculation of coefficients of the L-series attached to the l-adic Galois representations on Jacobian varieties with complex multiplication.

II. Publications

1. "Torsion points on hyperelliptic Jacobians via Anderson's p-adic soliton theory", Yuken Miyasaka, Takao Yamazaki, To appear in Tokyo journal of Mathematics (2013)
2. "Honda theory for formal groups of abelian varieties with complex multiplication", Hirokazu Shinjo,

Yuken Miyasaka, preprint.

III. Presentations

1. "Torsion points on Jacobian varieties and p-adic Sato theory", Yuken Miyasaka, workshop at IPMU (MS seminar), (July 3, 2012, Kavli IPMU, Japan)
2. "Torsion points on Jacobian varieties and p-adic Sato theory", Yuken Miyasaka, Colloquium, (November 13, 2012, Saga University, Japan)
3. "Honda theory for formal groups of abelian varieties of GL₂-type", Yuken Miyasaka, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.12

Name	Kazushige Nakagawa
Department	Mathematics
Position	Assistant Professor
Research Title	New developments of qualitative property for fully nonlinear partial differential equations of L_p-viscosity solutions

I. Summary of Research

1. The Aleksandrov-Bakelman-Pucci maximum principle is established for L_p-viscosity solutions of fully nonlinear second order elliptic PDEs having linear and superlinear growth terms for the first derivatives with small coefficients.
2. The Phragmen-Lindelof theorem is established for L_p-viscosity solutions of fully nonlinear second order elliptic partial differential weak coupled systems with unbounded coefficients and inhomogeneous terms.

II. Publications

1. Nakagawa, K., The Aleksandrov-Bakelman-Pucci maximum principle of fully nonlinear equations for small data and its applications, (revised).
2. Nakagawa, K., The Phragmen-Lindelof theorem for nonlinear weak coupled elliptic systems, (preprint).

III. Presentations

1. Nakagawa, K., The Phragmen-Lindelof theorem of fully nonlinear systems for L_p-viscosity solutions with unbounded ingredients. September 2012, MSJ 2012 Autumn meeting, Kyushu University, Kyushu.

2. Nakagawa, K., The Phragmen-Lindelof theorem for fully nonlinear elliptic systems with unbounded ingredients, Geometry of solutions of Partial Differential Equations, November 2012, RIMS Kyoto, Kyoto.
3. The Phragmen-Lindelof theorem for L_p -viscosity solutions of nonlinear weakly coupled elliptic systems, Fukae workshop on PDE (2013), January 2013, Kobe University, Kobe.
4. Nakagawa, K., The Phragmen-Lindelof theorem of nonlinear weakly coupled elliptic systems, The 14th Northeastern Symposium on Mathematical Analysis, February 2013, Tohoku University, Sendai.
5. Nakagawa, K., The Phragmen-Lindelof theorem of nonlinear weakly coupled systems with unbounded ingredients, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", March 2013, Tohoku University, Sendai.