4.2. GCOE Assistant Professor and Young Scientist Initiative B

The GCOE adopted 16 GCOE assistant professors in 2011 fiscal year, and supported the encouragement research expense as "Young Scientist Initiative B" for most of them. Their names and research titles are as listed below.　Then, their research reports are the following. There were 26 publications, and 54 presentations by the GCOE assistant professors.

1. **Takeshi Koike (Nuclear physics)**
   "Gamma-ray spectroscopy at J-PARC with Hyperball-J"

2. **Hidekatsu Nemura (Nuclear physics)**
   "Lambda-Nucleon and Sigma-Nucleon Potentials from lattice QCD"

3. **Yohei Matsuda (Nuclear physics)**
   " Elastic scattering of protons with RI beams"

4. **Tatsuro Yuge (Condensed matter physics)**
   "Quantum noise in solids - Application to quantum information and condensed matter physics"

5. **Mamoru Tanaka (Mathematics)**
   "A coarse embedding of a finitely generated group into a geodesic space with a convex metric"

6. **Mikito Tanaka (Astrophysics)**
   1. "Observational study of the formation history of M31's stellar halo using Subaru/Suprime-Cam",
   2. "Development and the practical research of lessons through collaborative learning for improving self-efficacy and career readiness of undergraduate students (Newly added later) "

7. **Shumpei Masuda (Condensed matter physics)**
   "Ideal manipulation of quantum states with Fast-forward scaling method"

8. **Dirk Puetzfeld (Astrophysics)**
   "Equations of motion in General Relativity"

9. **Tsuguhiko Asakawa (Particle physics)**
   "Research on the structure of spacetime in string theory from symmetry viewpoint"

10. **Yuichiro Kiyo (Particle physics)**

Phenomenology and QCD in high energy physics

11. **Satoshi Heguri (Condensed matter physics)**

"Quantum phase transition in type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$ system"

12. **Joji Nasu   (Condensed matter physics)**

"Novel Phenomena Appearing near Phase Boundary in Orbital Degenerate System"

13. **Takato Uehara (Mathematics)**

"Dynamical systems on complex surfaces"

14. **Masakazu Yamamoto (Mathematics)**

"Large time behavior of solutions to drift-diffusion system"

15. **Daisuke Nitta (Astrophysics)**

"Constraints on primordial non-gaussianity from cosmic micro wave background and large scale structure"

16. **Takahiro Okabe (Mathematics)**

"Asymptotic behavior of solutions of the nonlinear partial differential equations in fluid mechanism"

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. Recovery from the March 11, Great eastern Japan earthquake: Our Germanium detector system, Hyperball-J, which was under construction was severely damaged from the disaster. Furthermore, a scheduled beam time at J-PARC was cancelled because the accelerator has become inoperable until December, 2011.

2. Theoretical investigation of the moment of inertia of the rotational level of the light p-shell hypernuclei: Light nuclei such as ^{6}Li and ^{8}Be exhibit at their ground states di-cluster like structures. By adding a Lambda particle, the inter-cluster distance is expected to decrease due to glue like role of Lambda. Despite this drastic change of the structure, however, their corresponding energy spectra show a contradicting trend. Collaboration with a theorist led to a possible explanation for this, and the results has been published.

II. Publications

1. "Relation between shrinkage effect and compression of the rotational spectrum in the $_\Lambda^7$Li hypernucleus", K. Hagino and T. Koike, Phys. Rev. C 84, 064325 (2011)

III. Presentations

1. "A glue like effect of Lambda particle and moment of inertia of rotational bands of p-shell clustered nuclei", T.Koike, Workshop at RCNP (September 7-8, 201Ⅰ, RCNP, Ibaraki, Osaka, Japan)

2. "gamma-ray spectroscopy of sd-hsell nuclei at J-PARC", T.Koike, The 4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

3. "gamma-ray spectroscopy of $^{25}_\Lambda$Mg", T.Koike, Japan Physical Society 2012 Spring Meeting (March 24-27, 2012, Kansai Gakuin University, Nishinomiya, Hyogo, Japan)

No.2

Name	**Hidekatsu Nemura**
Department	**Physics**
Position	**Assistant Professor**
Research Title	**Interdisciplinary study of semiconductor quantum physics and nonequilibrium statistical physics Lambda-Nucleon and Sigma-Nucleon Potentials from lattice QCD**

I. Summary of Research

1. The central and tensor potentials of the Lambda-Nucleon are obtained from lattice QCD by taking account of time-dependent Schroedinger-type equation.

2. The central and tensor potentials of the Sigma-Nucleon with the isospin I=3/2 are also calculated by using similar way to the Lambda-Nucleon potentials.

3. The low energy scattering parameters (scattering length and effective range) are obtained from the potentials.

II. Publications

1. "Lambda-Nucleon potential calculated from lattice QCD", H. Nemura for HAL QCD collaboration, AIP Conf. Proc. 1388, 628-631 (2011)

2. "Extraction of hadron interactions above inelastic threshold in lattice QCD", S. Aoki, N. Ishii, T. Doi, T. Hatsuda, Y. Ikeda, T. Inoue, K. Murano, H. Nemura, and K. Sasaki, Proc. Jpn. Acad., Ser. B, Vol. 87, 509-517 (2011).

III. Presentations

1. "Baryon-baryon interaction of strangeness S=-1 sector", H. Nemura, The XXIX International Symposium on Lattice Field Theory, (July 11-16, 2011, The Village at Squaw Valley, Lake Tahoe, California, USA)

No.3

Name	**Yohei Matsuda**
Department	**Physics**
Position	**Assistant Professor**
Research Title	**Elastic scattering of protons with RI beams**

I. Summary of Research

1. The size is one of the fundamental properties of nuclei. Therefore, in order to measure radii and

density distributions of unstable nuclei, we have developed a recoil proton spectrometer (RPS), which consists of a solid hydrogen target, two recoil drift chambers, two plastic scintillators, and fourteen NaI(Tl) calorimeters. Using the RPS, we have measured carbon, oxygen, and nickel isotopes. From the data, the radius of 9C was determined this year. The result was reported at GCOE symposium, Kyoto University.

2. In order to study the equation of state for isospin symmetric/asymmetric nuclear matter, we submitted and approved two experimental proposals. Then we have prepared the experiments

II. Publications

1. "Scintillating fiber detector for momentum tagging light unstable nuclei at intermediate energies", <u>Y. Matsuda</u>, T. Kobayashi, M. Itoh, K. Ozeki, H. Sakaguchi, J. Zenihiro, Y. Iwao, H. Otsu, H. Takeda, S. Terashima, Nucl. Instr. and Meth. A 670 25 (2012)

2. "Large, thin solid hydrogen target using para-H2", <u>Y. Matsuda</u>, H.Sakaguchi, J. Zenihiro, S.Ishimoto,S.Suzuki, H.Otsu, T.Ohnishi, H.Takeda, K.Ozeki, K.Tanaka, S.Terashima, Y.Maeda, T.Kobayashi,A.Koreeda, K.Kamei, Nucl. Instr. and Meth. A 643 6 (2011).

III. Presentations

1. "Proton elastic scattering and the radius of 9C", Y. Matsuda, GCOE Symposium 'Links among Hierarchies', (Feb. 13-15, 2012. Kyoto University, Kyoto, Japan)

No.4

Name	**Tatsuro Yuge**
Department	**Physics (IIAIR)**
Position	**Assistant Professor**
Research Title	**Quantum noise in solids ― application to quantum information and condensed matter physics**

I. Summary of Research

1. A method is proposed for obtaining the spectrum for noise that causes the phase decoherence of a qubit directly from experimentally available data. The method is based on a simple relationship between the spectrum and the coherence time of the qubit in the presence of a π-pulse sequence. The relationship is found to hold for every system of a qubit interacting with the classical-noise, bosonic, and spin baths.

2. We consider pump-probe experiments on strongly-correlated electron systems in the presence of electron-phonon interactions and random potentials. Such a system is driven to a nonequilibrium state (NES) by a pump field(s), which is either an optical field or a longitudinal electric field. Since

the pump field is time dependent in general, so is the NES. For the differential optical conductivity describing differential response of such a NES to a probe optical field, we derive exact sum rules and asymptotic behaviors, which open wide possibilities of experiments. In deriving these results, we have also derived general results for differential response functions of general systems.

II. Publications

1. "Sum Rules and Asymptotic Behaviors for Optical Conductivity of Nonequilibrium Many-Electron Systems", A. Shimizu and T. Yuge, Journal of the Physical Society of Japan, Vol.80, No.9, p.093706 (2011).

III. Presentations

1. "Estimation of noise spectrum by multiple-pulse sequence", T. Yuge, S. Sasaki, and Y. Hirayama, The 24th Quantum Information Technology Symposium (May 12-13, 2011, Tokyo Institute of Technology, Tokyo, Japan)

2. "Measurement of noise spectrum by multiple-pulse sequence", T. Yuge, S. Sasaki, and Y. Hirayama, Japan Physical Society 2011 Autumn Meeting (September 21-24, 2011, Toyama University, Toyama, Japan)

3. "Sum and asymptotic rules for optical conductivity of nonequilibrium states in many-electron system", T. Yuge, and A. Shimizu, Japan Physical Society 2011 Autumn Meeting (September 21-24, 2011, Toyama University, Toyama, Japan)

No.5

Name	**Mamoru Tanaka**
Department	**Mathematics**
Position	**Assistant Professor**
Research Title	**Elastic Scattering of Protons with RI beams**

I. Summary of Research

1. We give relations between higher eigenvalues of the Laplacian on a finite graph, a generalized expander constant of the graph, and the first nonzero eigenvalues of the Laplacians on subgraphs in a partition of the graph. Using this, we show that a family of generalized expanders, which have uniform boundedness of higher order eigenvalues instead of uniform boundedness of 2nd eigenvalues, can be divided into families of expanders.

2. We prove that a family of finite graphs which contains a family of expanders as subgraphs is not coarsely embeddable into any Hilbert space. In particular, a family of generalized expanders is not coarsely embeddable into any Hilbert space.

II. Publications

1. "Higher eigenvalues and partitions of a graph", <u>Mamoru Tanaka</u>, submitted.

III. Presentations

1. "Property (T_B) and Property (F_B) restricted to an irreducible representation", M. Tanaka, Geometry seminar, (May, 17, 2011, Tohoku University, Sendai, Japan)

2. "On relations between partitions of finite graphs and eigenvalues of Laplacians", Sendai Max Dehn seminar, (December 22, 2011, Tohoku University, Sendai, Japan)

3. "The l-th eigenvalue of the Laplacian of a finite graph", Matsue seminar, (January 11, 2012, Shimane University, Matsue, Japan)

4. "Higher eigenvalues of the Laplacian on a graph and partitions of the graph", Combinatorics and Numerical Analysis Joint Workshop, (February 17, 2012, Kyushu University, Fukuoka, Japan)

5. "Higher eigenvalues of the Laplacian on a graph and partitions of the graph", The 4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

6. "The l-th eigenvalue of a finite graph", The 8th Mathematics Conference for Young Researchers, (February 27-March 1, 2012, Hokkaido University, Sapporo, Japan)

7. "On relations between partitions and eigenvalues of graphs", MSJ Spring Meeting 2012, (March 26-29, 2012 , Tokyo University of Science, Shinjuku, Tokyo, Japan)

No.6

Name	**Mikito Tanaka**
Department	**Astronomy**
Position	**Assistant Professor**
Research Title	**1. Observational study of the formation history of M31's stellar halo using Subaru/Suprime-Cam**
	2. Development and the practical research of lessons through collaborative learning for improving self-efficacy and career readiness of undergraduate students (Newly added later)

I. Summary of Research

1. We have conducted the pilot observation of a galactic globular cluster, NGC2419, using Subaru/Suprime-Cam. We have confirmed that the narrow band filter, NB515, which we made for Subaru/Suprime-Cam last year can quantitatively separate red giant branch stars from dwarf starsn on (g-i, g-NB515) color-color diagram. We have ordered NB515 filter for Hyper Suprime-Cam

based on the result (PI:Chiba)

2. We have investigated what our students learned through Moshiten and our lesson for the 3rd undergraduate students, based on the qualitative research method. In consequence, we found that they learned about their own career formation as well as astronomical expertise. Therefore, we have developed two unique lectures of astronomical liberal arts for the 1st undergraduate students characterized by collaborative learning for improving self-efficacy and career readiness of students (with Center for the Advancement of Higher Education, Tohoku University).

II. Publications

1. "Structure and Population of the NGC 55 Stellar Halo from A Subaru/Suprime-Cam Survey", Tanaka, M. et al. 2011, ApJ, 738, 150

2. "A spectroscopic survey of Andromeda's Western Shelf", Fardal, M. et al. (incl. Tanaka Mikito), 2012, submitted in MNRAS.

3. "GLOBAL PROPERTIES OF M31'S STELLAR HALO FROM THE SPLASH SURVEY: I. SURFACE BRIGHTNESS PROFILE", Gilbert, K. et al. (incl. Tanaka Mikito), 2012, submitted in ApJ

III. Presentations

1. "Reporting on work experience of astronomer for high school students (Moshiten) and applying to higher education", Mikito Tanaka, ASJ spring annual meeting, 2012, Ryukoku Univ, Kyoto, Japan

2. "Galactic Archaeology – Observational Studies of the Stellar Halo of the Andromeda Galaxy using Subaru telescope", Mikito Tanaka, Subaru users meeting, 2012, NAOJ, Mitaka, Japan

3. "Galactic Archaeology – Observational Studies of the Stellar Halo of the Andromeda Galaxy using Subaru telescope", Mikito Tanaka, The 4th GCOE International Symposium, 2012, Tohoku Univ., Sendai, Japan

4. "Andromeda Halo", Mikito Tanaka, PFS-GA team meeting. 2012, UT IPMU, Kashiwa, Japan

5. "First Time Galactic Archaeology", Mikito Tanaka, Germany-Japan Round Table 2011, 2011, Heidelberg Univ., Germany

6. "Structure and Population of the NGC55 Stellar Halo from a Subaru/Suprime-Cam Survey", Mikito Tanaka, The 3rd Subaru International Conference, 2011, Syuzenji, Izu, Japan

No.7

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 have studied the acceleration of quantum dynamics under electromagnetic field. We extend the fast-forward scaling method without electromagnetic field, and derive the driving field to accelerate quantum adiabatic dynamics.

2. We have studied the acceleration of quantum dynamics in many body systems. We have extended the theory to the many body system and derived the driving potential. We found a driving potential which accelerate the adiabatic transport of the same kind of particles. We also derived the driving potential for a particular state of many body systems.

3. We have studied the effect of uncontrollable random noise on the acceleration with fast-forward scaling. We found that the rapid acceleration with the fast-forward scaling decreases the disturbance on the quantum states due to the noise and is useful for quantum manipulation with less disturbances.

II. Publications

1. "Acceleration of adiabatic quantum dynamics in electromagnetic fields", S. Masuda, and K. Nakamura, Phys Rev B 84, 043434, (2011). (accepted at October 2011) Proceedings

2. "Acceleration of quantum transport under spatially random potential" S. Masuda, and K. Nakamura, Proceedings of 5th international workshop on fundamental physics using atoms p127-129 (2011).

3. "Manipulation of spin of conducting electron by topological insulator", S. Masuda, and Y. Kuramoto, Proceedings of international workshop: Recent advance in the physics of low dimensional nanoscale systems, p36-44 (2011)

III. Presentations

1. "Fast-forward theory in many body system", S. Masuda, The Physical Society of Japan Autumn Meeting 2012 (24th -27th March, Kwanseigakuin Univ, Hyogo, JAPAN)

2. "Interference effects of helical current of two dimensional topological insulator", S. Masuda, and Y. Kuramoto, The 4th GCOE international symposium on Weaving science web beyond particle-matter hierarchy, (20th-21st February 2012, Tohoku Univ, Sendai, JAPAN)

3. "Manipulation of spin of conducting electron by topological insulator", S. Masuda, and Y. Kuramoto, International workshop: Recent advance in the physics of low dimensional nanoscale systems (11th-12th November 2011, Uzbekistan national Univ, Tashkent, UZBEKISTAN)

4. "Acceleration of quantum transport under spatially random potential", <u>S. Masuda</u>, and K. Nakamura, 5th international workshop on fundamental physics using atoms (8th-10th October 2011, Okayama Univ, Okayama, JAPAN)

5. "Quantum chaos of two electrons in quantum wire", <u>S. Masuda,</u> S. Sawada and Y. Shimizu, The Physical Society of Japan Autumn Meeting 2011 (25th -28th September 2011, Toyama Univ, Toyama, JAPAN)

6. "Rapid transport of quantum states with fast-forward theory", <u>S. Masuda,</u> The Physical Society of Japan Autumn Meeting 2011 (25th -28th September 2011, Toyama Univ, Toyama , JAPAN)

No.9

Name	**Tsuguhiko Asakawa**
Department	**Physics**
Position	**Assistant Professor**
Research Title	**Research on the structure of spacetime in string theory from symmetry viewpoint**

I. Summary of Research

1. Equivalence between Nahm duality and T-duality

There is an equivalence, called the Nahm duality, between two gauge theories on two different 4-dimensional tori. It is related to T-duality in superstring theory, when these gauge theories are regarded as effective theories on D-branes. However, it is not clear the reason why these two dualities give the same answer.

We have formulated the 2-dimensional version of the Nahm transformation, and found that it includes extra sign, as expected from T-duality rule. In order to clarify discrepancy in this sign factor, we have compared directly two dualities at the level of boundary states for D-branes, and showed that they are equivalent with each other. Moreover, it has been shown that the sign problem is resolved by taking the transformation of the RR-potentials coupling to D-branes into account. This was the first paper to investigate T-duality with its sign carefully. As a byproduct, we have obtained a new representation of the representation of RR-potentials, which is more useful in practical calculations than the previous one.

2. 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 an 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.

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 127 No.4 (2012), to be published.

III. Presentations

1. "Noncommutative Solitons of Gravity", T. Asakawa, The 4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

No.11

Name	**Satoshi Heguri**
Department	**Physics**
Position	**Assistant Professor**
Research Title	**Quantum phase transition in type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$ system**

I. Summary of Research

1. We succeed to synthesize single crystal of type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$ with various compositions of x, and to occur quantum phase transition by composition control.

   Type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$ with composition from x = 8 to x = 0.5 showed ferromagnetic characteristics above 2 K. Saturated magnetization systematically decreased with decreasing composition. Especially, temperature dependence of magnetic susceptibility of $Eu_{0.1}Sr_{7.9}Ga_{16}Ge_{30}$ showed Curie-Weiss behavior. Electrical resistance minimum and logT dependence were observed below 2 K in this sample. These results strongly suggested Kondo effect. We continue to study about this phenomenon.

2. We proposed that anomalous in temperature dependence of electrical resistivity of $Eu_8Ga_{16}Ge_{30}$ arises from interaction between fluctuation of localized electron and spin instability.

   Among of type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$, $Eu_2Sr_6Ga_{16}Ge_{30}$ was designed based on unique concept which adopted site selectivity derived from deferent size of guest ion. In this phase, all Eu

atoms are accommodated in the smaller cages. It means that Eu atoms do not show the anharmonic vibration. We compared properties of this phase to that of $Eu_8Ga_{16}Ge_{30}$, therefore, we discussed about anomalous physical properties associated with anharmonic vibrations of Eu atoms. As a results, we could propose one of the reason about anomalous in temperature dependence of electrical resistivity of $Eu_8Ga_{16}Ge_{30}$ below T_{Curie}.

II. Publications

1. "Coexistence of Dirac-cone state and superconductivity in iron pnictide $Ba(Fe_{1-x}Ru_xAs)_2$", Y. Tanabe, K. K. Huynh, S. Heguri, G. Mu, T. Urata, J. Xu, R. Nouchi, N. Mitoma, K. Tanigaki, Physical Review B, 84, 100508, (2011)

2. "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", G. Mu, J. Tang, Y. Tanabe, J. Xu, S. Heguri, K. Tanigaki, Physical Review B, 84, 054505, (2011)

III. Presentations

1. "Anharmonic vibration of guest atoms induced anomalous physical properties in type-1 clathrate", S. Heguri, Joint seminar in Department of Physics, (January 24, 2012, University of Hyogo, Kamigohri, Akoh, Japan)

2. "Vibrations of guest atoms induced anomalous physical properties in type-1 clathrate", S. Haguri, The 4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

3. "Guest atom vibrations induced low-energy state in type-1 clathrate $Eu_8Ga_{16}Ge_{30}$", S. Heguri, Y. Tanabe, P. Quynh, J-T. Xu, J. Tang, K. Tanigaki, Japan Physical Society 2011 Spring Meeting (March 25-28, 2011, Niigata University, Niigata, Japan)

4. "Physical properties of type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$ at low-temperature region", S. Heguri, Y. Tanabe, J-T. Xu, G. Mu, J. Wu, K. Tanigaki, Japan Physical Society 2011 Autum Meeting (March 21-24, 2011, Toyama University, Toyama, Japan)

5. "Electrical resistivity measurements under applied magnetic field in type-1 clathrate $Eu_xSr_{8-x}Ga_{16}Ge_{30}$", S. Heguri, Y. Tanabe, P. Quynh, J-T. Xu, J. Tang, K. Tanigaki, Japan Physical Society 2011 Spring Meeting (March 24-27, 2012, Kwansai Gakuin University, Nishinomiya, Hyogo, Japan)

No.12

Name	**Joji Nasu**
Department	**Physics**
Position	**Assistant Professor**
Research Title	**Novel Phenomena Appearing near Phase Boundary in Orbital Degenerate System**

I. Summary of Research

1. We study an orbital compass model on a checkerboard lattice where orbital degree of freedom is represented by the pseudo-spin operator. Competition arises from an Ising interaction for the z component of pseudo-spins along the vertical/horizontal bonds and an Ising interaction for the x component along diagonal bonds. Classical and quantum compass models are analyzed by utilizing several analytical methods and numerical simulations. At a fully frustrated point where the two Ising interactions compete with each other, a macroscopic number of orbital configurations are degenerate in a classical ground state. This degeneracy is lifted by thermal and quantum fluctuations, and a staggered long-range order of the z component of the pseudo-spin is realized. A tricritical point for this order appears due to competition between the bond dependent Ising interactions. Roles of geometrical frustration on excitation dynamics are also examined.

2. Two-dimensional orbital compass model is studied as an interacting itinerant electron model. A Hubbard-type tight-binding model, from which the orbital compass model is derived in the strong coupling limit, is identified. This model is analyzed by the random-phase approximation (RPA) and the self-consistent RPA methods from the weak coupling. Anisotropy for the orbital fluctuation in the momentum space is qualitatively changed by the on-site Coulomb interaction. This result is explained by the fact that the dominant fluctuation is changed from the intra-band nesting to the inter-band one by increasing the interaction.

II. Publications

1. "Orbital Compass Model as an Itinerant Electron System", J. Nasu and S. Ishihara, Europhys. Lett. 97, 27002-1-6 (2012).

2. "Ordering and Excitation in Orbital Compass Model on a Checkerboard Lattice", Joji Nasu, Synge Todo, Sumio Ishihara, arXiv:1203.3683.

III. Presentations

1. "Dynamical Jahn-Teller effect in spin-orbital coupled system", J. Nasu, and S. Ishihara: 2012 American Physical Society, March Meeting, P8.00008, Boston, Massachusetts, March, 2012

2. "Dynamical Jahn-Teller effect in spin-orbital coupled system", J. Nasu, and S. Ishihara: The 4th

GCOE International Symposium, Parallel Session A-2, Sendai, February, 2012

3. "Study of Orbital Degenerate System in Frustrated Checkerboard Lattice", J. Nasu, and S. Ishihara: CIFAR/MEXT Japanese Network MEETING, Vancouver, May, 2011

No.13

Name	**Takato Uehara**
Department	**Mathematics**
Position	**Assistant Professor**
Research Title	**Dynamical systems on complex surfaces**

I. Summary of Research

1. In the previous year, we constructed many examples of rational surface automorphisms with positive entropy by means of realizations of orbit datum. A realization consists of quadratic birational maps on the projective plane with the property that the orbit of each backward indeterminacy point of the maps reaches some forward one, which is described by an orbit data. Moreover we established a necessary and sufficient condition for the existence of a realization of a given orbit data, when the maps of the realization preserve a cubic curve with a cusp. It turns out that the automorphism constructed from the realization preserves a cuspidal anticanonical curve. In this year, we show the converse problem, namely, show that a given automorphism preserving a cuspidal anticanonical curve is constructed from some realization of an orbit data. Hence the method may help us to construct and study much more automorphisms.

2. We consider automorphism groups on rational surfaces which admit cuspidal anticanonical curves and have automorphisms with positive entropy. By applying Coxeter theory, we show that the automorphism groups on the surfaces are isomorphic to the infinite cyclic group.

II. Publications

1. "Rational Surface Automorphisms Preserving Cuspidal Anticanonical Curves", preprint.
2. "Automorphism Groups of Rational Surfaces", preprint.

III. Presentations

1. "On automorphisms preserving cuspidal anticanonical curves", <u>Takato Uehara</u>, Geometry Seminar (October 4, 2011, Tohoku University, Sendai, Japan)

2. "On automorphisms of rational rational surfaces", <u>Takato Uehara</u>, Geometry Colloquium, (November 9, 2011, Hokkaido University, Sapporo, Japan)

3. "Rational surface automorphisms preserving cuspidal anticanonical curves", <u>Takato Uehara</u>, Automorphisms of Algebraic Varieties-Dynamics and Arithmetic (December 19-23, 2011,

Shirahama, Japan)

4. "On rational surface automorphisms", <u>Takato Uehara</u>, Integrated Research on Complex Dynamics, (January 23-27, 2012, Kyoto University, Kyoto, Japan)

5. "Ergodic theory of Painlevé VI", <u>Takato Uehara</u>, The 4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

6. "On automorphisms of rational surfaces", <u>Takato Uehara</u>, Workshop of Algebraic Geometry in Kyushu for Young Researchers, (March 12-14, 2012, Kyushu University, Fukuoka, Japan)

No.14

Name	**Masakazu Yamamoto**
Department	**Mathematics**
Position	**Assistant Professor**
Research Title	**Large time behavior of solutions to drift-diffusion system.**

I. Summary of Research

1. We consider the initial-value problem for the drift-diffusion equation with generalized dissipation. We obtain the asymptotic expansion and the spatial analyticity of the solution.

2. (joint work with professor Shuichi Kawashima and Mr. Ryo Kobayashi) We consider the stationary problem for the drift-diffusion equation. We obtain the existence and the asymptotic stability of stationary solutions.

II. Publications

1. "Spatial analyticity of solutions to the drift-diffusion equation with generalized dissipation", <u>M. Yamamoto</u>, Arch. Math. (Basel), 97, 261-270, (2011)

2. "Asymptotic stability of stationary solutions to the drift-diffusion model in the whole space", R. Kobayashi, <u>M. Yamamoto</u>, S. Kawashima, to appear in ESAIM Control Optim. Calc. Var.

3. "Large-time behavior of solutions to the drift-diffusion equation with fractional dissipation", <u>M. Yamamoto</u>, to appear in Differential Integral Equations.

III. Presentations

1. "Large-time behavior of solutions to the drift-diffusion equation with local effect", M. Yamamoto, NLPDE Seminar (July 8, 2011, Kyoto University, Kyoto, Japan)

2. "Asymptotic behavior of solutions to the drift-diffusion equation with generalized dissipation", M. Yamamoto, Mathematical Society of Japan 2011 Autumn Meeting (September 30, 2011, Shinshu University, Matsumoto, Nagano, Japan)

3. "Special case for the asymptotic profile of the solutions to the drift-diffusion equation", M. Yamamoto, Colloquium (January 27, 2012, Ehime University, Matsuyama, Ehime, Japan)

No.15

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 cosmic microwave background (CMB) bispectra induced by the graviton non-Gaussianities, which arise from the parity-conserving and parity-violating Weyl cubic terms with time-dependent coupling. By considering the time-dependent coupling, we find that even in the exact de Sitter space time, the parity violation still appears in the three-point function of the primordial gravitational waves and could become large.

2. We have studied the black holes shadows in de Sitter space-time using the Kastor-Traschen cosmological multi- black hole solution that is an exact solution describing the collision of maximally charged black holes with a positive cosmological constant. We find that in addition to the shadow of each black hole, an eyebrowlike structure appears as the black holes come close to each other. These features can be used as probes to find the multiblack hole system at the final stage of its merger process.

II. Publications

1. "Parity Violation of Gravitons in the CMB Bispectrum", Maresuke Shiraishi, Daisuke Nitta, Shuichiro Yokoyama, PTP, 126 (2011), 937-959.

2. "Optimal limits on primordial magnetic fields from CMB bispectra of intensity modes", Maresuke Shiraishi, Daisuke Nitta, Shuichiro Yokoyama, Kiyotomo Ichiki, arXiv:1201.0376 (accepted for publication in JCAP, 2012).

III. Presentations

1. "Shadows of multi-black hole in de-Sitter space-time", Daisuke Nitta, The 4th GCOE International Symposium (February 20-22, Sendai, JAPAN)

No.16

Name	**Takahiro Okabe**
Department	**Mathematics**
Position	**Assistant Professor**
Research Title	**Asymptotic behavior of solutions of the nonlinear partial differential equations in fluid mechanism**

I. Summary of Research

1. We investigate the asymptotic behavior of the weak solutions to the Navier-Stokes equations in the half-space. More precisely, we establish the lower bound of energy decay of the solution of the Navier-Stokes equation under condition on the profile of the initial data.

2. We study of the uniqueness of the weak solution of the Navier-Stokes equations in general domains in the uniform C^2 class. We show the uniqueness theorem for the weak solutions which belongs to the critical Serrin's class $L^\infty(0,T;L^n)$.

II. Publications

1. "Lower bound of L^2 decay of the Navier-Stokes flow in the half-space R^n_+ and its asymptotic behavior in the frequency space", submitted

III. Presentations

1. "Lower bound of L^2-decay of the Navier-Stokes flow in the half space R^n_+," Takahiro Okabe, RIMS Workshop on Mathematical Analysis in Fluid and Gas Dynamics, (July 6-8, 2011, RIMS, Kyoto University, Kyoto Japan)

2. "Lower bound of L^2-decay of the Navier-Stokes flow in the half space R^n_+," Takahiro Okabe, 33th Wakate PDE seminar, (August 26-29, 2011, Tukuba, Japan)

3. "Lower bound of L^2-decay of the Navier-Stokes flow in the half space R^n_+," Takahiro Okabe, 4th MSJ-SI Nonlinear Dynamics in Partial differential equations, (September 12-21 2011, Kyusyu University, Fukuoka, Japan)

4. "Slow decay of the Navier-Stokes flow in the half space and asymptotic behavior in the frequency," Takahiro Okabe, Mathematical Society of Japan autumn meeting 2011, (September 28-October 1, 2011, Shinshu University, Matsumoto, Japan)

5. "Lower bound of L^2 decay of the Navier-Stokes equations in the half space R^n_+", Takahiro Okabe, Nagoya PDE seminar, (November 21, Nagoya University, Nagoya, Japan)

6. "Initial profile for the slow decay of the Navier-Stokes flow in the half-space," Takahiro Okabe, Workshop on PDE in Fluid Mechanics for young researcher, (January 5-6, Nagoya University, Nagoya, Japan)

7. "Initial profile for the slow decay of the Navier-Stokes flow in the half-space", Takahiro Okabe, The

4th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (February 20-22, 2012, Tohoku University, Sendai, Japan)

8. "Initial profile for the slow decay of the Navier-Stokes flow in the half-space", Takahior Okabe, Mathematical Society of Japan 2012 Spring Meeting (March 26-29, 2012, Tokyo University of Science, Tokyo, Japan)