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 Eu₉Sr₈₋₅Ga₁₆Ge₃₀ 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”
**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**


**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, 2011, RCNP, Ibaraki, Osaka, 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

III. Presentations

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 $^9\text{C}$ 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


III. Presentations


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 $\pi$-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

III. Presentations
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


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)
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 stars on (g-i, g-NB515) color-color diagram. We have ordered NB515 filter for Hyper Suprime-Cam
4. Research Reports in 2011 Fiscal Year: 4.2. GCOE Assistant Professor & Young Scientist Initiative B

Tohoku University GCOE program
"Weaving Science Web beyond Particle-Matter Hierarchy"

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

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
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
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


III. Presentations


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-Goldstone (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

III. Presentations

Name
Satoshi Heguri

Department
Physics

Position
Assistant Professor

Research Title
Quantum phase transition in type-1 clathrate Eu_xSr_8-xGa_16Ge_30 system

I. Summary of Research
1. We succeed to synthesize single crystal of type-1 clathrate Eu_xSr_8-xGa_16Ge_30 with various compositions of x, and to occur quantum phase transition by composition control.

   Type-1 clathrate Eu_xSr_8-xGa_16Ge_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_0.1Sr_7.9Ga_16Ge_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_xGa_16Ge_30 arises from interaction between fluctuation of localized electron and spin instability.

   Among of type-1 clathrate Eu_xSr_8-xGa_16Ge_30, Eu_2Sr_6Ga_16Ge_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$_8$Ga$_{10}$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$_8$Ga$_{10}$Ge$_{30}$ below $T_{\text{Curie}}$.

II. Publications


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)


5. “Electrical resistivity measurements under applied magnetic field in type-1 clathrate Eu$_8$Sr$_{8-x}$Ga$_{10}$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, Kansai Gakuin University, Nishinomiya, Hyogo, Japan)
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


III. Presentations


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


III. Presentations

1. “On automorphisms preserving cuspidal anticanonical curves”, Takato Uehara, Geometry Seminar (October 4, 2011, Tohoku University, Sendai, Japan)


3. “Rational surface automorphisms preserving cuspidal anticanonical curves”, Takato Uehara, Automorphisms of Algebraic Varieties-Dynamics and Arithmetic (December 19-23, 2011,
Shirahama, 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


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)

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 microwave 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


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 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 $\mathbb{R}^n_+$ 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 $\mathbb{R}^n_+$,” 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 $\mathbb{R}^n_+$,” 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 $\mathbb{R}^n_+$,” 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 $\mathbb{R}^n_+$”, 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)