No.1

Name **Higashi**

Department **Physics**

Position **D3**

Research Title **RA: Numerical study of quantum many-body effects in two-dimensional electron systems under strong magnetic fields**

I. Summary of Research

Graphene is a two-dimensional carbon material with honeycomb lattice and has massless Dirac-type low-energy spectrum. The relativistic nature of the low-energy dispersion relation of electrons in graphene strongly modifies the effective Coulomb interaction between electrons under magnetic field. In this year, to analyze the effects of the modified interaction the ground state of the interacting Dirac electrons in a high Landau level (index N=2) is examined by a combination of numerical techniques on the torus geometry: the exact diagonalization (ED) method and the density matrix renormalization group (DMRG) method. The DMRG method provides the low-energy eigenvalues and corresponding eigenvectors of the Hamiltonian within a restricted number of basis states and exactly treats many-body interactions. Thus we can treat large systems beyond the limitation of the ED method and take into account of the effects of quantum fluctuations which are neglected in the Hartree-Fock approximation. The ground state energy, excitation gap, and pair correlation functions are systematically calculated at various fillings from ν=1/9 to 1/2. Also, by the use of the ED method we analyze the ground state wave function overlap between the exact few-particle wave function and the candidate variational wave function (i.e., the Laughlin state for ν=1/(2m+1)) for the incompressible fractional quantum Hall state. The obtained results for systems with up to 24 electrons confirm the existence of various electronic states. It is shown that the ground state phase diagram consists of incompressible quantum liquid states exhibiting the fractional quantum Hall effect, compressible liquid-like states, and various types of charge density waves called stripes, bubbles, Wigner crystal, and so on.

II. Publications

III. Presentations

1. “Ground state phase diagram of interacting Dirac electrons in graphene under magnetic field”, Tatsuya Higashi, The 5th GCOE International Symposium on “Weaving Science Web beyond Particle-Matter Hierarchy”, (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.2

Name **Kenji Hosomi**

Department **Physics**

Position **D3**

Research Title **RA: Study of ΛN interaction via hypernuclear γ-ray spectroscopy experiment with 12C target**

I. Summary of Research

A γ-ray spectroscopy experiment of $^{11}_{\Lambda}$B and $^{12}_{\Lambda}$C was performed at KEK-PS K6 beam line in 2005 for the investigation of the spin-dependent ΛN interactions including the ΛΣ coupling effect. A further analysis of the experimental data has been continued. As a result, we succeeded in observing a new γ-ray peak attributed to $^{12}_{\Lambda}$C. This peak was identified to be the M1 transition from the 6-MeV excited state to the ground state.

The energy spacing of the $^{12}_{\Lambda}$C ground-state spin doublet observed in the experiment is well explained with the ΛΣ effect from the Nijmegen NSC97f model. Since the energy spacing of this doublet is very sensitive to the ΛΣ effect, our experimental result strongly suggests that the ΛΣ interaction of the NSC97f model is reasonable. It is also pointed out that the ΛΣ effect still plays an important role in *p*-shell hypernuclei even though the effect is smaller than that for *s*-shell hypernuclei.

We also performed a hybrid missing mass spectroscopy method, where the mass spectrum in coincidence with specified γ-ray events was obtained. As a result, a new peak at 16-MeV excitation energy was observed for the first time. Although more theoretical studies are necessary, we suggest the assignment of the $^{12}_{\Lambda}$C state with a Λ hyperon in the *d* orbit for this peak.

II. Publications

III. Presentations

1. "Gamma-ray spectroscopy of $^{12}_{\Lambda}$C via the (π^+, K^+) reaction", K. Hosomi for the KEK-E566 collaboration, The 11th International Conference on Hypernuclear and Strange Particle Physics (HYP2012), October 1-5, 2012, COSMOCAIXA, Barcelona, Spain
2. "Gamma-ray spectroscopy of $^{11}_{\Lambda}$B and $^{12}_{\Lambda}$C", K. Hosomi for the KEK-E566 collaboration, The 5th GCOE International Symposium "Weaving Science Web beyond Particle-Matter Hierarchy", March 4-6, 2013, Tohoku University, Sendai, Japan

No.3

Name	**Brian Beckford**
Department	**Physics**
Position	**D 3**
Research Title	**RA: Study of the strangeness photoproduction process in the threshold energy region**

I. Summary of Research

1. In the course of the last year, I have further studie the production of strangeness by the electromagnetic interaction by chiefly focusing on the production of Λ. Due to the efforts I have successfully completed the analysis of obtained data and have written an extensive dissertation to report the findings. Along with this I presented the preliminary results at the International workshop on strangeness nuclear physics in Osaka and at the 5th GCOE symposium. Lastly, I was able to successfully defend my results and be awarded a Ph.D.

II. Publications

1. "Measurement of the photon induced production of Λ in the 2H(γ, Λ)X reaction"
   B.Beckford, et al..arXiv:1210.7585 [nucl-ex] (2012)
2. "Neutral Kaon Photoproduction in the threshold region",
   B.Beckford, et al. AIP conf. Proc. 1388 (2011) 280

III. Presentations

1. "Λ Photoproduction on a deuteron at threshold energies"
   B. Beckford,
   The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-5, 2013, Tohoku University, Sendai, Japan)
2. "Measurement of the photon induced production of Λ in the d(γ, Λ)X reaction",
   B. Beckford,
   International workshop on strangeness nuclear physics. (August 27-29, 2012, Osaka Electro-Communication University, Osaka, Japan)

No.4

Name **Yasuhiro Takemoto**

Department **Physics**

Position **D3**

Research Title **RA: Observation of the 7Be Solar Neutrinos with KamLAND**

I. Summary of Research

1. Research Background

KamLAND collaboration had focused on observation of the ^{7}Be solar neutrinos. The observation was done since Feb. 2009 to Aug. 2011, subsequently to the twice purification of the KamLAND liquid scintillator, which had ~10^{5} times higher background rate against predicted the ^{7}Be solar neutrino event rate. After the purification, background rate inside KamLAND fell compatible to the predicted ^{7}Be solar neutrino event rate.

2. Research.

In this fiscal year, ^{7}Be solar neutrino analysis with KamLAND data has been done.

Main difficulty of this research is that higher background regions varied temporally and spatially due to destabilization of temperature gradient inside KamLAND. Due to this variation, it is difficult to set a fixed observation region, but choosing only low-background regions induces possible systematical biases. Hence this research is mostly focused in statistically valid treatment of the various overwhelming background against ^{7}Be solar neutrinos. My analysis method first merges temporally and spatially segmented data pieces into several data sets according to the background rate, then fits the data sets simultaneously. This method avoids inducing sytematical biases by including high background data and emphasizes low background data, and gives a positive result.

3. Results

The summary of this research is reported in four presentations listed below.

In the KamLAND collaboration meeting, the methods and the analysis result from this research are generally accepted affirmatively.

The analysis method has almost established and the summary results are still now analyzed. The results are going to be summarized in a physics paper.

II. Publications

1. “Measurement of the double-β decay half-life of ^{136}Xe with the KamLAND-Zen experiment”, A. Gando et al, KamLAND-Zen Collaboration, Physical Review C, 85, 045504, (2012)
2. “Limits on Majoron-emitting double-β decays of ^{136}Xe in the KamLAND-Zen experiment”, A. Gando et al, KamLAND-Zen Collaboration, Physical Review C, 86, 021601(R), (2012)

3. "Limit on Neutrinoless ββ Decay of ^{136}Xe from the First Phase of KamLAND-Zen and Comparison with the Positive Claim in ^{76}Ge", A. Gando et al, KamLAND-Zen Collaboration, Physical Review Letters, (2013) (Accepted on January, 9th, 2013, and not yet published)

III. Presentations

1. "Observation of the ^{7}Be Solar Neutrinos with KamLAND", Takemoto Yasuhiro, the KamLAND Collaboration, Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Kyoto, Japan)
2. "Be7 solar neutrino analysis", Takemoto Yasuhiro, KamLAND Collaboration meeting (October 7-10, 2012, Hawaii University, Manoa, Hawaii, The United States)
3. "Observation of the ^{7}Be Solar Neutrinos with KamLAND", Takemoto Yasuhiro, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)
4. "Be7 solar neutrino analysis ", Takemoto Yasuhiro, KamLAND Collaboration meeting (March 18-20, 2013, Okuhida Sougou Bunka Center, Gifu, Japan)

No.5

Name	**Azusa Gando**
Department	**Physics**
Position	**D 3**
Research Title	**RA: Search for neutrinoless double-beta decay with KamLAND-Zen**

I. Summary of Research

1. KamLAND-Zero neutrino double beta decay (KamLAND-Zen) searches for neutirnoless double-beta decay of ^{136}Xe with xenon loaded liquid scintillator. An observation of the decay would establish the Majorana nature of neutrino and prove lepton number violation. The decay rate can be translated into the effective neutrino mass if the decay is mediated by a light Majorana neutrino, which is the most commonly discussed. Some models predict decays with the emission of a new boson Majoron and the effective Majoron-neutrino coupling constant would be evaluated.
2. KamLAND-Zen started data taking on September 2011. Results are summarized based on the data taken from October 12, 2011 to February 9, 2012, corresponding to the exposure of 112.3 days livetime times 125 kg of ^{136}Xe. The two-neutrino double-beta decay half-life of ^{136}Xe is measured to be $T^{1/2}(2\nu) = 2.30 \pm 0.02(\text{stat}) \pm 0.12(\text{syst}) \times 10^{21}$ yr. This most precise result is consistent with the recent direct measurement. It supports the conclusion that the directly measured half-life is significantly below the lower limit reported by earlier experiments. The precision measurement of the half-life allows a more accurate determination of the nuclear matrix element (NME) of the decay.

The evaluated value will be used to improve the calculation of the NME of neutrinoless double-beta decay, which causes the largest uncertainty in determining the effective neutrino mass.

No signal of neutrinoless double-beta decay has been observed. We set a lower limit for the half-life of the decay as $T^{1/2}(0\nu) > 6.2 \times 10^{24}$ yr at 90% C.L., corresponding to the upper limit on the effective neutrino masses of 0.26−0.54 eV at 90% C.L. using recent QRPA and shell model NMEs. Such top-level sensitivity has been achieved just by initial attempt. Half-lives of Majoron-emitting neutrinoless double-beta decay with spectral index n = 1, 2, 3 and 7 are also estimated. As for "ordinary" decay (n = 1), we have obtained lower limit of half-life as $T^{1/2}(0\nu\chi^0) > 2.6 \times 10^{24}$ yr at 90% C.L. and the corresponding upper limit on the effective Majoron-neutrino coupling constant is less than $(0.8-1.6)\times10^{-5}$ at 90% C.L. This result is the most stringent limit on the effective Majoron-neutrino coupling constant for all double-beta decay nuclei and excludes a previously unconstrained region. The extended limit strongly constrains the possible contribution of ordinary Majoron emitting decay to the light Majorana neutrino exchange in the inverted hierarchy scheme.

II. Publications

1. "Measurement of the double-β decay half-life of ^{136}Xe with the KamLAND-Zen experiment",
   A. Gando et al. (KamLAND-Zen Collaboration),
   Physical Review C 85, 045504 (2012).
2. "Limits on Majoron-emitting double-β decays of ^{136}Xe in the KamLAND-Zen experiment",
   A. Gando et al. (KamLAND-Zen Collaboration),
   Physical Review C 86, 021601(R) (2012).

III. Presentations

1. [Invited] "Results from KamLAND-Zen",
   Azusa Gando for the KamLAND-Zen Collaboration,
   The 4th International Conference Current Problems in Nuclear Physics and Atomic Energy (September 3-7, 2012, Kyiv, Ukraine)
2. [Oral] "KamLAND-Zen; Summary of pre-purification data and the current status",
   Azusa Gando for the KamLAND-Zen Collaboration,
   Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)

IV. Prizes (Awards)

1. Department Director's Award of Physics for the doctoral thesis of "First Results of Neutrinoless Double Beta Decay Search with KamLAND-Zen", (March, 2013)

No.6

Name **omohiro Oishi**
Department **Physics**
Position **D3**
Research Title **RA/Initiative A: Microscopic Analysis of Two-Proton Radioactivity**

I. Summary of Research

In this fiscal year I studied the two-proton decay or radioactivity which is a novel decay-mode observed for proton-rich unstable nuclei. From theoretical point of view, the microscopic description including all "final-state interactions'' (FSIs) between the decay products is necessary. Additionally, recent theoretical and experimental studies show that there are not only the FSIs but also the initial state configuration of two protons being responsible for the decay properties. I have partially succeeded to develop the reliable method which is referred to as "time-dependent approach'' (TDA). With this method I obtained some outcomes as follows.

1. As the benchmark test of the TDA to the two-proton radioactivity, in the former half of this fiscal year, I performed the one-dimensional three-body (Core + proton + proton) model calculation. There were shown some qualitative properties, such that the mechanism of the two-proton decay is critically affected by the interactions between all particles in the final state (FSIs). Moreover with strong proton-proton interaction the decay-mode named ``di-proton decay'' where two protons are simultaneously emitted as a subsystem with total spin = 0 become dominant. These results were summarized and published as Phys. Rev. C86, 044301(2012), and also presented in some conferences.
2. In the latter half of this fiscal year I studied the two-proton radioactive nuclides with a realistic three-dimensional model. As preliminary results the two-proton Q-value and decay-width of Be-6 and Ne-16 nuclei are calculated. These theoretical values are in fair agreement with experiments for Be-6, but in poor for Ne-16 where the discrepancies are in 10 to 100 orders for the decay-width. This disagreement is a crucial problem and requires further improvements in the theoretical side which includes, for example, the employment of the effective three-body interaction. Another task is to extrapolate the effect of the initial configuration on the decay process. This effect is well described with TDA, which has a strong point to discuss whether the ``di-proton correlation'' can be detected from the experiments of two-proton decays. I am now working on both problems. These results were partially reported in some meetings and conferences including COMEX4.

II. Publications

1. "Time-dependent approach to many-particle tunneling in one dimension'',
Takahito Maruyama, Tomohiro Oishi, Kouichi Hagino, Hiroyuki Sagawa, Physical Review C86, 044301, 2012.

III. Presentations

1. “Time-dependent approach to two-nucleon radioactivity’’, T. Oishi, K. Hagino, H. Sagawa, RCNP Meeting ``Resonance and reaction-dynamics near the nuclear threshold’’ (July 18-20, 2012, RCNP Osaka University, Ibaraki, Osaka, Japan).
2. “Time-dependent approach to two-proton radioactivity’’, T. Oishi, K. Hagino, H. Sagawa, 11th CNS Summer School (August 29 - September 4, 2012, CNS University of Tokyo, Wako, Saitama, Japan).
3. “Time-dependent approach to two-neucleon radioactivity in three-body-model’’, T. Oishi and K. Hagino, Japan Physical Society 2012 Autumn Meeting (September 10-14, 2012, Kyoto Sangyo University, Kyoto, Kyoto, Japan).
4. “Time-dependent approach to two-proton radioactivity’’ (Poster), T. Oishi, K. Hagino, H. Sagawa, COMEX4 (October 22-26, 2012, Shonan Village Center, Hayama, Kanagawa, Japan).
5. “Time-dependent approach to two-proton radioactivity and di-proton correlation’’ (Poster), T. Oishi, K. Hagino, H. Sagawa, 5th International GCOE-symposium on ``Weaving Science Web beyond Particle-Matter Hierarchy’’ (March 4-6, 2013, Tohoku University, Sendai, Japan).
6. “Time-dependent approach to two-proton radioactivity’’, T. Oishi, K. Hagino, H. Sagawa, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan).

No.7

Name	**Yutaka Ohya**
Department	**Physics**
Position	**D3**
Research Title	**RA/Initiative A: Dynamic Theory for Polymer-Containing Bio -Membranes**

I. Summary of Research

Polymer-containing bio-membranes in a flow field show interesting structures not only from the viewpoint of biological science but also of industrial science, because these membranes can be regarded as a simple model of drug-delivery system. We simulated this model by developing a field theoretical method. For example, we use phase field theory for deformation of the bio-membrane, self consistent field theory for the polymer conformations and Navier-stokes equation for the external flow field. Coupling these theories, we simulated behaviors of polymer-containing bio-membranes in a narrow blood vessel. In figure 1, we show simulation results of deformations of bio-membranes. Figure 1(a) shows a typical deformation of a bio-membrane without polymers, i.e. the parachute shape, which is often observed for a red-blood cell in a narrow blood vessel. Figure 1(b) shows the behavior of a polymer-containing bio-membrane. In this case, we observe that the shape deformation of the

bio-membrane is suppressed, which should be attributed to the effect of the elasticity of the polymers inside the membrane.

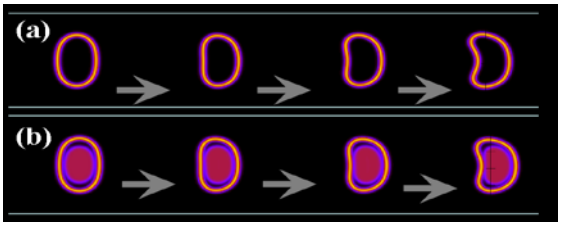


Figure1. A model of bio-membranes in a narrow blood vessel. Figures (a) and (b) are for the cases without and with the polymers inside the membrane, respectively.

II. Publications

1. "Field Theoretical Approach for a Polymr-Containing Vesicle",
   Yutaka Oya, and Toshihiro Kawakatsu, *Nanosci. Nanotechnol*, **4**, 015010, (2013).
2. "Field Theoretical Approach for Bio-Mmembrne Coupled with Flow Field",
   Yutaka Oya, and Toshihiro Kawakatsu, AIP Conference Proceeding (accepted).

III. Presentations

Oral presentations

1. "Field Theories for Dynamic Behaviors of Vesicle" (in Japanese),
   Yutaka Oya and Toshihiro Kawakatsu, Japan Physical Society 2012 Autumn Meeting (September 18-21, Yokohama National University, Kanagawa, Japan).
2. "Field Theoretical Approach for Polymer-Containing Bio-Membrane",
   Yutaka Oya and Toshihiro Kawakatsu, The 6th International Workshop on Advanced Materials Science and Nanotechnology (IWAMSN) 2012 (October 30 - November 2, Ha Long City, Vietnam).

Poster presentations

3. "Field Theoretical Approach for Bio-Membrane Coupled with Flow Field",
   Yutaka Oya and Toshihiro Kawakatsu, The 4th International Symposium on Slow Dynamics in Complex Systems (December 2-7, Tohoku University, Sendai, Japan).
4. "Dynamics Theory for Polymer-Containing Bio-Membranes",
   Yutaka Oya and Toshihiro Kawakatsu, The 5th International GCOE Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan).

No.8

Name **Chigusa Kimura**

Department **Physics**

Position **D3**

Research Title **RA: Double pion photoproduction on deuteron**

I. Summary of Research

1. In this year, I have analyzed experimental data which our group obtained at the ELPH in energy region of $0.7 \leqq E\gamma \leqq 1.1$ GeV. I have repeated calibration for counters and the resolution of the particle identification is improved and background events are rejected clearly.
2. Selection of $\gamma d \rightarrow \pi^+ \pi^- d$ events were refined and their yield were obtained.
3. I have done Monte Carlo simulation of the events. I used simulation result to decide some cut condition for data and to obtain analysis efficiencies.

II. Publications

1. "Measurements of the photon induced production of Λ in the $^2H(\gamma,\Lambda)X$ process at threshold energies", B. Beckford, P. Bydzovsky, A. Chiba, D. Doi, T. Fujii, Y. Fujii, K. Futatsukawa, T. Gogami, O. Hashimoto, Y.C. Han, K. Hirose, S. Hirose, R. Honda, K. Hosomi, T. Ishikawa, H. Kanda, M. Kaneta, Y. Kaneko, S. Kato, D. Kawama, C. Kimura, S. Kiyokawa, T. Koike, K. Maeda, K. Makabe, M. Matsubara, K. Miwa, S. Nagao, S.N. Nakamura, A. Okuyama, K. Shirotori, K. Sugihara, K. Suzuki, T. Tamae, H. Tamura, K. Tsukada, K. Yagi, F. Yamamoto, T.O. Yamamoto, H. Yamazaki, Y. Yonemoto, arXiv:1210.7585, (2012)

III. Presentations

1. "Study of $\gamma d \rightarrow \pi^+ \pi^- d$ reaction in an energy region of $0.67 \leqq E\gamma \leqq 1.08$ GeV",
   C. Kimura for the NKS2 Collaboration, The 20th International IUPAP Conference on Few-Body Problems in Physics (August 20-25, 2012, Fukuoka International Congress Center ,Fukuoka, Japan)
2. "The $\gamma d \rightarrow \pi^+\pi^- d$ reaction in the energy region of $0.7 \leqq E\gamma \leqq 1.1$ GeV",
   C. Kimura for the NKS2 Collaboration, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.9

Name **Zenmei Suzuki**

Department **Physics**

Position **D3**

Research Title **RA: Measurement of CP-violating angle ϕ_3 at Belle experiment**

I. Summary of Research

1. The measurement of CP-violating angle ϕ_3 is very important in terms of the verification of the Standard Model and search for new physics. However, the ϕ_3 accuracy is not so good, because $B \to DK$ (D : D^0 or $\overline{D^0}$) decay that is used for ϕ_3 measurement is rare decay. This study is aimed for measurement of ϕ_3 using $B^\pm \to DK^\pm$, $D \to K_S K^\pm \pi^\mp$. There is not yet an effective result using this decay.
2. In the last fiscal year, I understood that there are many resonances in the $D \to K_S K^\pm \pi^\mp$ decays. Thus it is need to study $D \to K_S K^\pm \pi^\mp$ Dalitz distribution. However, the fitting of $B^\pm \to DK^\pm$, $D \to K_S K^\pm \pi^\mp$ Dalitz distribution is very difficult because this decay has small statistics and cannot be distinguished between D^0 and $\overline{D^0}$. Therefore, in this fiscal year, I studied $D^{*\pm} \to D\pi^\pm$, $D \to K_S K^\pm \pi^\mp$ to model the Dalitz distribution of $D \to K_S K^\pm \pi^\mp$. This decay has high statistics and can identify D flavor by the charge of D^*. I have confirmed whether the fitting of Dalitz distribution is consistent using the Monte Carlo (MC) simulation. Then I studied the background events of this mode because of characteristic behavior. As a result, it is realized that the resolution of Dalitz plane affects fitting result. The resolution effect is introduced to the fitting.
3. The fitting method of Dalitz plane has been confirmed from many sides. In the next step, I will determine the decay model of $D \to K_S K^\pm \pi^\mp$ using the real data.
4. Toy-MC study of $B^\pm \to DK^\pm$, $D \to K_S K^\pm \pi^\mp$ is done, it is confirmed that the systematic error of ϕ_3 from the D* study is negligible.

II. Publications

III. Presentations

1. "Study of $B \to DK$, $D \to K_S K\pi$ for the measurement of CP-violating angle ϕ_3, and $D^* \to D\pi$, $D \to K_S K\pi$ for the modeling of $D \to K_S K\pi$ Dalitz plane", Zenmei Suzuki, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.10

Name	**Yoshiro Teshima**
Department	**Physics**
Position	**D3**
Research Title	**RA: The relationship between various analytical techniques of T-duality**

I. Summary of Research

1. This year, I researched the relationship between various analytical techniques of T-duality. First I clarified the equivalence of the bound state analysis with the Nahm transformation, considering the D2/D0 bound state in superstring theory. Unlike the 4-dimensional case, there appears a minus sign in a topological charge, which seems puzzling when it is regarded as a D-brane charge. To give the interpretation of this minus sign, I reformulated boundary states in the RR-sector using a new representation of zeromodes, and show that the RR-coupling is invariant under the T-duality. Finally, the T-duality invariance at the level of the Chern-Simon coupling is shown by deriving the Buscher rule for the RR-potentials, known as the 'Hori formula', including the correct sign.

II. Publications

1. “Boundary state analysis on the equivalence of T-duality and Nahm transformation in superstring theory”, T. Asakawa, Y. Teshima, U. Carow-Watamura and S. Watamura, arXiv:1201.0125v2 [hep-th] (17 Jan 2012)

III. Presentations

1. “The relationship between various analytical techniques of T-duality”, Yoshiro Teshima. The 5th International GCOE symposium, (March 4-6, 2012, Tohoku University, Sendai, Japan)

No.11

Name	**Takao Fujii**
Department	**Physics**
Position	**D3**
Research Title	**RA: Research of Kaon photoproduction process in the threshold resion**

I. Summary of Research

1. The purpose of this research is to measure the total cross section of $\gamma d \rightarrow K^{+}\Lambda n$ and $\gamma d \rightarrow K^{0}\Lambda p$ reactions in the threshold energy region. The experimental data of photoproduction on the deuteron have been taken in 2010 with the Neutral Kaon Spectrometer 2 (NKS2). In this year, I put emphasis

on the analysis of $\gamma d \rightarrow K^+ \Lambda n$ reaction. I developed new analysis method for this reaction in the NKS2 data analysis. In this reaction, the Λ particle is detected by its charged decay, $\Lambda \rightarrow p\pi^-$, and the K^+ is detected directly. Firstly, I searched 3 charged tracks in the drift chamber, and chose the event that each tracks were K^+, p and π^- by the particle identification. Secondary, I constructed the decay vertex of the Λ particle, and the Λ was detected by the $p\pi^-$ invariant mass. And the K^+ was detected using the momentum and the energy deposit at hodoscopes.

2. To estimation of detector acceptance, I carried out the simulation for both of $\gamma d \rightarrow K^+ \Lambda n$ and $\gamma d \rightarrow K^0 \Lambda p$ reactions. And the analysis of simulation data is on going.

II. Publications

1. "Measurements of the photon induced production of Λ in the $^2H(\gamma,\Lambda)X$ process at threshold energies", B. Beckford, P. Bydzovsky, A. Chiba, D. Doi, T. Fujii, Y. Fujii, K. Futatsukawa, T. Gogami, O. Hashimoto, Y.C. Han, K. Hirose, S. Hirose, R. Honda, K. Hosomi, T. Ishikawa, H. Kanda, M. Kaneta, Y. Kaneko, S. Kato, D. Kawama, C. Kimura, S. Kiyokawa, T. Koike, K. Maeda, K. Makabe, M. Matsubara, K. Miwa, S. Nagao, S.N. Nakamura, A. Okuyama, K. Shirotori, K. Sugihara, K. Suzuki, T. Tamae, H. Tamura, K. Tsukada, K. Yagi, F. Yamamoto, T.O. Yamamoto, H. Yamazaki, Y. Yonemoto, arXiv:1210.7585, (2012)

III. Presentations

1. "Exclusive study of Λ photoproduction in the threshold region" T. Fujii, 6 Senkou Symposium of the Graduate School of Science, (Feb. 21, 2013, Tohoku University, Sendai, Japan)
2. "Exclusive study of Λ photoproduction in the threshold region" T. Fujii, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.12

Name	**Morioka Takayuki**
Department	**Physics**
Position	**D3**
Research Title	**RA/Initiative A: Multiple-order parameter coupling and non-trivial magnetic structure in multiferroic materials**

I. Summary of Research

To understand order parameters of various magnetic field induced phase transition about multiferroic materials TbMnO3 , where magnetic and ferroelectric orders coexist, we have performed measurement neutron diffraction under high pulse magnetic fields at J-PARC. We observed the change of Bragg peaks,

when a pulsed magnetic field is applied up to 40 T. The result show that the peak corresponding to Tb moments disappears and the peak corresponding to Mn moments shifts to the commensurate position.

II. Publications

1. "Multiferroic $FeTe_2O_5Br$: Alternating spin chains with frustrated interchain interactions" M. Pregelj, H. O. Jeschke, H. Feldner, R. Valenti, A. Honecker, T. Saha-Dasgupta, H. Das, S. Yoshii, T. Morioka, H. Nojiri, H. Berger, A. Zorko, O. Zaharko, and D. Arcŏn (PHYSICAL REVIEW B **86**, 54402, (2012))

III. Presentations

1. "Development for Pulse High Magnetic Field for Neutron Diffraction at J-PARC", T. Morioka, H. Nojiri, Y. Narumi, S. Yoshii, M. Baker, and K. Ohoyama, Summit of Materials Science,(November 27-30, 2012, Institute for Materials Research, Sendai, Japan)
2. "Magneto-electric Coupling of Low-dimentional Magnetic Correlation System in Multiferroic $FeTe_2O_5Br$", T. Morioka, H. Hiroyuki, M. Masashi, M. Pregelj, D. Arcŏn, International Symposium on Electron Spin Science, (November 27-30, 2012, Institute for Materials Research, Sendai, Japan)
3. "Development for Pulse High Magnetic Field for Neutron Diffraction at J-PARC", T. Morioka, H. Nojiri, Y. Narumi, S. Yoshii, M. Baker, and K. Ohoyama, Japan Physical Society 2012 Autumn Meeting,(September 18-21, 2012, Yokohama National University, Yokohama, Japan)
4. "Polarized Neutron Diffraction Measurement under Pulsed High Magnetic Fields", T. Morioka, H. Nojiri, Y. Narumi, S. Yoshii, M. Baker, and K. Ohoyama, Japan Physical Society 2013 Spring Meeting,(March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.13

Name	**Yuki Yamaki**
Department	**Physics**
Position	**D3**
Research Title	**RA: Study of x-ray induced phase transition in impurity doped layered manganites**

I. Summary of Research

In this year, I have investigated x-ray induced phase transition in impurity doped layered manganites systematically. The results are summarized below.

1. Phase-separated state between the charge-orbital ordered and ferromagnetic phases is realized by impurity doping.
2. In this phase-separated region, x-ray induced persistent and bidirectional phase transition between

charge-orbital ordered and ferromagnetic phases was observed.

3. In the present case, impurity doping plays a crucial role in forming the phase-separated state and also in determining the rate of x-ray induced phase transition.

II. Publications

1. "Impurity effect on orbital ordering and magnetic property in $La_{0.5}Sr_{1.5}MnO_4$", Y. Yamaki, H. Nakao, Y. Yamasaki, Y. Murakami, Y. Kaneko, and Y. Tokura, Journal of Physics: Conference Series **400**, 042071 (2012).
2. "Dopant-dependence on Charge-orbital Order in Impurity Doped Layered Manganites", Y. Yamaki, H. Nakao, Y. Yamasaki, Y. Murakami, Y. Kaneko, and Y. Tokura, Journal of Korean Physical Society, *accepted for publication*.

III. Presentations

1. "Dopant-dependence on charge/orbital order in impurity doped layered manganites", Y. Yamaki, H. Nakao, Y. Yamasaki, Y. Murakami, Y. Kaneko, and Y. Tokura, The 19th International Conference on Magnetism, (July 8-13, 2012, BEXCO, Busan, Korea).
2. "Dopant dependence on x-ray photo-induced phase transition in $La_{0.5}Sr_{1.5}MnO_4$", Y. Yamaki, Y. Yamasaki, H. Nakao, Y. Murakami, Y. Kaneko, and Y. Tokura, Japan Physical Society 2012 Autumn Meeting, (September 18-21, 2012, Yokohama National University, Yokohama, Japan).
3. "Dopant dependence of x-ray induced phase transition in impurity doped layered manganites", Y. Yamaki, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan).

No.14

Name	**Shusaku Yusa**
Department	**Physics**
Position	**D3**
Research Title	**RA/Initiative A: Role of noncollective excitations in low-energy heavy-ion reactions**

I. Summary of Research

1. We summarized the study of the noncollective excitations in $^{16}O + ^{208}Pb$ reaction which was carried out in the last year. We submitted a paper, which has been already published in Phys. Rev. C.
2. In this year, we continued the study of the noncollective excitations in low-energy heavy-ion reactions and investigated the role of the noncollective excitations in $^{20}Ne + ^{90,92}Zr$ systems. In order to include the noncollective excitations in the coupled-channels calculation, we employed a random

matrix model. This model was introduced to study heavy-ion deep inelastic collisions by Weidenmüller *et al.* in the 1970's and is based on the random matrix theory.

We first applied the random matrix model to ^{16}O + ^{208}Pb reaction in order to see the applicability of the model for the description of the noncollective excitations. For ^{16}O + ^{208}Pb system, we had studied the effect of the noncollective excitations on fusion reaction and quasi-elastic scattering by using the experimental information on the noncollective states of ^{208}Pb. We confirmed that the random matrix model can reasonably reproduce the calculation which uses the experimental information for the description of the noncollective excitations.

We then applied the model to quasi-elastic scattering for ^{20}Ne + ^{90,92}Zr systems. For the excitation energy and the spin-parity of the noncollective states of Zr isotopes, we used the experimental data, while the coupling matrix elements to each noncollective state were estimated by the random matrix model. By explicitly taking into account the noncollective excitations, we showed that the magnitude of the effect of the noncollective excitations is considerably different between ^{20}Ne + ^{90}Zr and ^{20}Ne + ^{92}Zr systems. That is, the calculated quasi-elastic barrier distribution for ^{20}Ne + ^{92}Zr system exhibits much more smeared behavior, compared to that of ^{20}Ne + ^{90}Zr system. Although the complete agreement with the data for quasi-elastic scattering cross sections has not been obtained, the difference between the calculated quasi-elastic barrier distributions for ^{20}Ne + ^{90,92}Zr systems was found to be consistent with the experimental data. We also calculated the Q-value distribution for these systems by taking into account the noncollective excitations. Our results indicate that, at subbarrier energies, the contribution from the collective channels is dominant, while the contribution from the noncollective excitations becomes more and more important as the incident energy increases. This tendency is similar to that of ^{16}O + ^{208}Pb system. We also investigated the effect of the noncollective excitations on fusion reaction for ^{24}Mg + ^{90,92}Zr systems, and showed that the different behavior of the barrier distributions can be expected as in the case of ^{20}Ne + ^{90,92}Zr systems.

We are preparing a paper on these results to be submitted to a research journal.

II. Publications

1. "Role of noncollective excitations in heavy-ion fusion reactions and quasi-elastic scattering around the Coulomb barrier", S. Yusa, K. Hagino, and N. Rowley, Phys. Rev. C **85**, 054601 (2012).

III. Presentations

1. "Applicability of random matrix model to low-energy heavy-ion reactions", S. Yusa, K. Hagino, N. Rowley, Japan Physical Society 2012 autumn Meeting, (September, 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)
2. "Applicability of random matrix model to low-energy heavy-ion reactions", S. Yusa, K. Hagino, and N. Rowley, The 4th international conference on "Collective Motion in Nuclei under Extreme Conditions" (COMEX4), (October, 22-26, 2012, Shonan Village Center, Kanagawa, Japan)

3. “Role of noncollective excitations in low-energy heavy-ion reactions”, S. Yusa, The 5th International GCOE symposium on “Weaving Science Web beyond Particle-Matter Hierarchy” (March, 4-6, 2013, Tohoku University, Sendai, Japan)

No.15

Name	**Takayuki Watanabe**
Department	**Physics**
Position	**D3**
Research Title	**RA: Interaction betwee**n pho**tons and mechanical oscillation in GaAs-based mechanical resonators**

I. Summary of Research

I study about interaction between photons and mechanical oscillation in GaAs-based mechanical resonators through observation of mechanical motion. The interaction is generated by excited carriers in the mechanical resonator through piezoelectric effect. The research topics are two. First, I studied mode temperature control of thermal vibration using laser irradiation. The mode temperature was successfully controlled and especially 50 % reduction of the mode temperature was observed. A part of the study was published. Second, I studied about forced actuation of mechanical motion by optical irradiation using piezoelectricity. Especially, frequency response of mechanical motion is studied. It is clarified that delay time of mechanical response to the optical irradiation was clarified and absorption coefficient is also precisely evaluated from it. The delay time estimation is very important result because it is one of the important parameter which decides the efficiency of mechanical motion. The absorption coefficient measurement has several advantage compared to well known optical property measurement and it can become a complementary measurement technique. I partially revealed features of the interaction between photons and mechanical interaction through these study.

II. Publications

1. “Optomechanical photoabsorption spectroscopy of exciton states in GaAs”, Watanabe T., Okamoto H., Onomitsu K., Gotoh H., Sogawa T. & Yamaguchi H., Appl. Phys. Lett., 101, 082107 (2012)

III. Presentations

1. “Cavity-free laser cooling of a GaAs/AlGaAs micromechanical resonator using optical absorption at exciton states” T. Watanabe, 31st International Conference on the Physics of Semiconductors (July 29-August 3, 2012, Zurich, Switzerland)
2. “Mechanical Q control of a AlGaAs/GaAs cantilever using optical absorption at exciton state” T. Watanabe, The 17th International Conference on Molecular Beam Epitaxy (September 23-28, 2012,

Nara, Japan)

3. "Piezoelectric Optical-absorption Spectroscopy of a GaAs/AlGaAs Heterostructure using Cantilever Mechanical Resonance" T. Watanabe, 25th International Microprocesses and Nanotechnology Conference (October 30-November 2, 2012, Kobe, Japan)
4. "Piezoelectric optical-absorption spectroscopy of a GaAs/AlGaAs heterostructure using cantilever mechanical resonance", T.Watanabe, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.16

Name	**Masanori Watahiki**
Department	**Physics**
Position	**D3**
Research Title	**RA: Neutron scattering study in pyrochlore-type iridates $R_2Ir_2O_7$ (R = Nd, Tb) with metal-insulator transition**

I. Summary of Research

1. We carried out inelastic neutron scattering measurements to identify crystalline electric field (CEF) states of Nd^{3+} (a total angular momentum $J = 9/2$) in $Nd_2Ir_2O_7$ and Tb^{3+} ($J = 6$) in $Tb_2Ir_2O_7$.
   Inelastic neutron scattering experiments were performed using Fermi chopper spectrometer 4SEASONS and disc-chopper-type spectrometer AMATERAS installed at the MLF in the J-PARC. Powder samples of $Nd_2Ir_2O_7$ and $Tb_2Ir_2O_7$ were prepared by K. Matsuhira.
   In $Nd_2Ir_2O_7$, excitation peaks observed at around 26, 42 and 117 meV are interpreted as CEF excitations within five Kramers doublets. However, the last doublet was not observed below incident neutron energy $E_i = 309$ meV.
   Analysis models of CEF in $Nd_2Ir_2O_7$ and $Tb_2Ir_2O_7$ are in progress.

II. Publications

1. "Successive phase transitions induced by magnetic fields in a cubic system, $NdPd_3S_4$", M. Watahiki, E. Matsuoka, K. Iwasa, Y. Matsumoto, S. Nakamura, T. Nojima, K. Ohoyama, K. Tanigaki, H. Aoki and H. Onodera, J. Phys.: Conf. Ser. **391** (2012) 012076.
2. "Resonant X-ray diffraction study of multipole ordering in the ferromagnetic compound $CePd_3S_4$", S. Michimura, T. Inami, E. Matsuoka, M. Watahiki, K. Tanigaki, and H. Onodera, J. Phys. Soc. Jpn. 81 (2012) 044711.

III. Presentations

1. "Crystalline electric field study in $Nd_2Ir_2O_7$ with metal-insulator transition", M. Watahiki *et al.*, The

5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

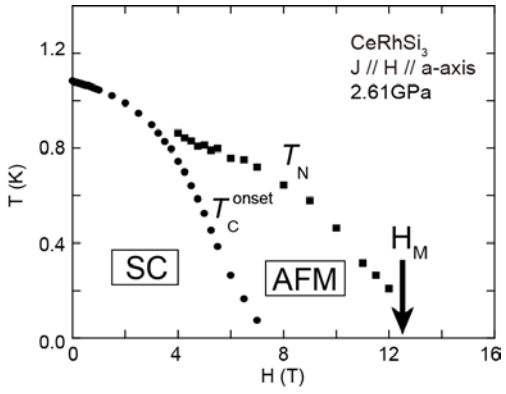
No.17

Name	**Hiroki Iida**
Department	**Physics**
Position	**D2**
Research Title	**RA/Initiative A: Comprehensive study of superconductivity in noncentrosymmetric heavy-fermion Ce113**

I. Summary

The heavy-fermion system provides a good playground to study novel superconductivity and non-Fermi-liquid (NFL) behavior emerging in the vicinity of magnetic quantum critical point (QCP). In this fiscal year, we obtained following results:

1. In order to verify the existence of a filed-induced QCP in $CeRhSi_3$, we have performed the electrical resistivity measurements under magnetic fields. We then revealed magnetic-field-temperature phase diagrams at several pressures. For 2.61 GPa, we determined the quantum-phase transition field H_M where the antiferromagnetic order disappears (Fig.1). If H_M is the QCP, Fermi-liquid behavior is expected to be observed above H_M in low temperatures. However, the NFL behavior with $r(T) = r_0 + AT^n$ ($n < 2$) persists above H_M (Fig.2). That is, recovery to Fermi-liquid state is not clearly observed above H_M. Therefore, H_M is not conclusively determined the QCP, further investigation is required.
2. In order to elucidate the QCP in $CeRhSi_3$, we have prepared de Haas–van Alphen (dHvA) effect measurement under pressures. Single crystals of $CeRhSi_3$ were grown by the Czochralski pulling method in a tetra-arc furnace. In order to obtain a high purity sanple, we optimized the ratio of starting material. We finally obtained single crystals with enough quality to detect a dHvA signal even in a pressure cell.



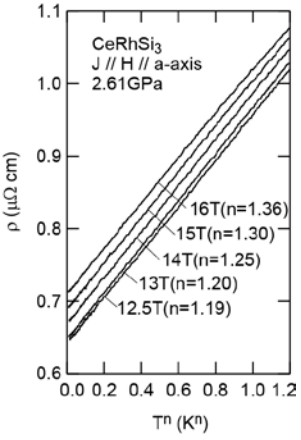


Figure1: T-H phase diagrams at 2.61GPa

Figure2: Resistivity of CeRhSi3 plotted against T^n

II. Publications

1. "Search for a quantum critical point in CeRhSi3 via electrical resistivity", H. Iida, T. Sugawara, H. Aoki, N. Kimura, to be published in Physical status solidi (b).

III. Presentations

1. "Verification of the Quantum Critical Point in $CeRhSi_3$ via Electrical Resistivity", H. Iida, International Conference on Quantum Criticality and Novel Phases 2012 (August 26-29, 2012, Dreikönigskirche, Dresden, Germany)
2. "Search for a field-induced quantum critical point in $CeRhSi_3$", H. Iida, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)
3. "Electronic State and Superconducting of Heavy Fermion $CeRhSi_3$ II", H. Iida, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Japan)

No.18

Name	**Toru Ito**
Department	**Physics**
Position	**D2**
Research Title	**RA: The new type of the fractional quantum Hall effect in N=1 Landau level**

I. Summary of Research

In this year, I studied an novel order. That is called topological order. In fractional quantum Hall states, the topological order appears in the spectrum of entanglement entropy. The topological order gives the universal correction in the scaling law of entanglement entropy. That correction is called topological entanglement entropy. I calculated topological entanglement entropy for several types of the quantum Hall states. Then I confirmed realization of the topological orders in several quantum Hall states.

Further, I calculate the topological entanglement entropy for some fractional filling where the ground state is not decided though quantum Hall effect is observed. Then I find the possibility of the parafermion ground state. In the parafermion state, electrons take Bose condensate by forming clusters which are like a Cooper pair. The quasiparticle excitation in that state has non-abelian statistics. Realizing Topological-quantum-computer is considered by using this statistics. My study increase the possibility of realization quantum computing.

II. Publications

1. “Spin-Orbit Interaction enhanced Fractional Quantum Hall States”, Toru Ito, Kentaro Nomura, Naokazu Shibata, Journal of the Physical Society of Japan, Vol 79, (2010) 16147
2. “ Quantum Phase Transition Induced by Spin-Orbit Interaction in The N=1 Landau Level”, Toru Ito, Kentaro Nomura, Naokazu Shibata, Journal of the Physical Society of Japan, Vol 81, (2012) 64934.
3. “Quasi-particle tunneling in anti-Pfaffian quantum Hall state”, Journal of the Physical Society of Japan

III. Presentations

1. “The effect of the spin-orbit interaction for fractional quantum Hall states”, Toru Ito, Japan Physical Society 2010 Autumn Meeting (September 23-26, 2010, Osaka Prefecture University, Osaka, Japan)
2. “The effect of the spin-orbit interaction for several fractional quantum Hall states”, Toru Ito, Japan Physical Society 2011 Annual Meeting (March 25-28, 2011, Niigata University, Niigata, Japan)
3. “The Tunneling Effect Inter Edges of the Anti-Pfafian State , Toru Ito, Japan Physical Society 2012 Annual Meeting (March 24-27, 2012, Kansai Gakuin University, Hyogo, Japan)
4. “Quantum Phase Transitions Induced by Spin-Orbit Interaction in the N = 1 Landau Level” HMF20: High Magnetic Field in Semiconductor Physics, Chamonix Mont-Blanc, France, July 2012,

No.19

Name	**Yasuko Urata**
Department	**Physics**
Position	**D2**
Research Title	**RA: Structure of neutron-rich nucleus deduced from nuclear reactions**

I. Summary of Research

1. Interaction cross sections as well as reaction cross sections are intimately related to the size of nuclei. Using this property, the halo structure with an extended density distribution has been found in some light neutron-rich nuclei. Recently, a large interaction cross section for ^{31}Ne was observed by Takechi *et al.*, and suggests the halo structure of ^{31}Ne. Assuming that ^{31}Ne consists of the deformed core nucleus ^{30}Ne and a weakly bound valence neutron, we have been studying the structure of the ^{31}Ne nucleus by taking into account the rotational excitation of the core nucleus with a non-adiabatic particle-rotor model (PRM). We calculated the reaction cross section for ^{31}Ne with PRM and

compared to the experimental data. We found that the calculated reaction cross section with the configuration at the deformation parameter of β_2~0.2 is consistent with the measured interaction cross section. We also found that there is only a small difference between the cross section in the adiabatic limit and that with the finite rotational excitation energy of the core nucleus.

2. Glauber theory with the optical limit approximation (OLA) has generally used to calculate reaction cross sections. Beyond the optical limit approximation, there are two methods to take into account the multiple scattering, that is, Suzuki's method and Few-body method. We investigated the relation between these two methods and OLA.

II. Publications

1. "Reaction cross sections of the deformed halo nucleus ^{31}Ne", Y. Urata, K. Hagino and H. Sagawa, Physical Review C, 86, 044613, (2012)

III. Presentations

1. "Comparison of reaction cross sections in the region beyond the optical limit approximation using Glauber theory", Y. Urata and K. Hagino, Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)
2. "Coulomb breakup and reaction cross sections of the deformed halo nucleus ^{31}Ne", Y. Urata, K. Hagino and H. Sagawa, Collective motions in nuclei under extreme conditions (COMEX4) (October 22-26, 2012, Shonan village center, Hayama, Japan)
3. "Reaction cross sections of the deformed halo nucleus ^{31}Ne", Y. Urata, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.20

Name	**Shuhei Sasa**
Department	**Physics**
Position	**D2**
Research Title	**RA: Geometrical background in string theory and its low-energy effective theory** **Initiative A: Geometry behind string theory and its low-energy effective theory**

I. Summary of Research

1. Dirac-Born-Infeld (DBI) action gives the low-energy effective theory of a D-brane. It can be derived by calculating scattering amplitudes in string theory. However it is not obvious why DBI action. If

some mechanisms characterize the effective theory of the D- brane and explain the reason why DBI action gives the effective theory, we may decide higher order corrections to DBI action without higher-order computation. As one such method, it is known that DBI action is invariant under the non-linearly realized Lorentz symmetry, which is broken by putting the D-brane on the target space. There, the scalar fields describing transverse displacements of the D-brane become NG bosons for broken translational symmetries.

We propose a new evedence for why DBI action by considering D-branes in the framework of generalized geometry proposed by Hitchin. In this framework, we show that the scalar fields and a gauge field on a D-brane can be treated in an equal footing and the argument about the non-linear realization of the spontaneously broken symmetries can be extended to include the gauge field and the NS-NS B-field.

2. T-duality is a remarkable feature in string theory. T-duality is a symmetry under which two different compactified spaces with a U(1) isometry are indistinguishable from the viewpoint of string theory. More concretely, a metric and a NS-NS B-field are mixed under T-duality by Buscher's formula. After taking T-duality, the metric and the B-field become in general ill-defined globally as fields. It indicates that space-time geometry in string theory must be formulated in a framework beyond a usual geometry in point particle theory. Non-geometric spaces are examples of such stringy geometry.

   Given a field theory on a manifold with local coordinate patches, all fields on intersections of the patches must be glued with symmetries of the theory. On the other hand, unlike point particle theory, symmetries in string theory allow not only diffeomorphism and gauge transformations, but also T-duality. So the fields in string theory may be glued with T-duality on the intersections. The resulting space glued with T-duality are called non-geometric spaces.

   We formulate a theory on the non-geometric space extending the generalized geometry proposed by Hitchin. In this framework, we discuss a low-energy effective theories of string theory in the non-geometric space.

II. Publications

1. “D-branes in Generalized Geometry and Dirac-Born-Infeld Action”, T. Asakawa, S. Sasa, S. Watamura, JHEP 1210, 064 (2012)

III. Presentations

1. “New geometric interpretation of D-brane and DBI action”, T. Asakawa, S. Sasa, S. Watamura, YITP Conference on “Field Theory and String Theory” 2012 (August 19-23, 2012, KEK, Tsukuba, Ibaraki, Japan)
2. “Gravity theory in the bulk from the D-brane viewpoint and non-geometric spaces”, T. Asakawa, S.

Sasa, S. Watamura, Japan Physical Society 2012 Spring Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)

3. "Generalized geometric approach to non-geometric space", T. Asakawa, S. Sasa, S. Watamura, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.21

Name	**Satoshi Yamazaki**
Department	**Physics**
Position	**D2**
Research Title	**RA: The study of superconductivity in low-carrier system** **Initiative A: The study of exotic superconductor induced by strong electron-phonon interaction**

I. Summary of Research

In this year, I studied about behaviors of systems with strong electron-phonon coupling. These systems are interesting because of highly retarded interaction between electrons. However, the fully quantum-mechanical treatment of electron-phonon interaction has received comparatively little attention. We investigate a superconducting state in Holstein-Hubbard model by combining dynamical mean field theory with a continuous time quantum Monte Carlo method.

In last year, we calculate the superconducting transition temperature (T_c) which depends on electron-phonon interaction strength g and Coulomb repulsion U. We showed that T_c for $U=0$ case has a maximum as a function of g and exponentially decreases in the strong coupling regime. This rapid decrease of T_c is caused by strong localized character of electron pairs induced by electron-phonon coupling. For $U>0$, on the other hand, we find that Coulomb interaction enhances T_c in the strong coupling region because electron pairs acquire coherence by local depairing effect of Coulomb interaction. We also calculated a carrier dependence of T_c. For some parameter, T_c increases as the carrier decrease.

II. Publications

III. Presentations

1. "Quantum Monte Carlo study of strong coupling superconductivity in Holstein-Hubbard model" Satoshi Yamazaki, Yoshio Kuramoto, Japan Physical Society 2012 Autumn Meeting (September 18-21, 2012, Yokohama National University, Kanagawa, Japan)
2. "Continuous Time Quantum Monte Carlo study of strong coupling superconductivity in Holstein-Hubbard model" Satoshi Yamazaki, Yoshio Kuramoto, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.22

Name **Fumiya Yamamoto**
Department **Physics**
Position **D2**
Research Title **RA: Study of double delta photoproduction on the deuteron target**

I. Summary of Research

I studied double delta photoproduction in 2012 fiscal year. The experiment was carried out at Research Center for Electron Photon Science (ELPH), Tohoku University. Neutral Kaon Spectrometer 2 (NKS2) was used for the detection of charged particles. It consists of dipole magnet with magnitude 0.42 T, two sets of drift chambers in the magnetic field, and inner and outer hodoscopes.

I calculated a position resolution of drift chamber using a simulation. The simulation is executed when the position resolutions are 0.5 – 0.9 mm at intervals of 0.1 mm, and the experimental position resolution is derived by comparing a residual distribution of simulation with it of experiment. The residual distribution is the difference of the closest points of between a wire and a track obtained from tracking and a position obtained from drift time. As a result, the position resolution of each layers were about 0.5 – 0.7 mm (Fig.1).

Double delta photoproduction is a reaction which the two nucleons excited simultaneously to the delta by an intermediate state in double pion photoproduction on the deuteron. Since the two nucleons involve in the reaction, it is allow us to investigate about the interaction of nucleon – nucleon or resonance – resonance. When only the proton is involved in the reaction, the neutron should follow Fermi momentum in the deuteron. Therefore, an event of neutron momentum above 0.3 GeV/c is selected as a reaction which involved two nucleons. As a method of examining double delta production, an invariant mass distribution of π^+p and π^-n is used. The invariant mass is shown in Fig.2. Since the event was concentrating near delta mass 1232 MeV/c^2, it turned out that it goes via delta in the intermediate state.

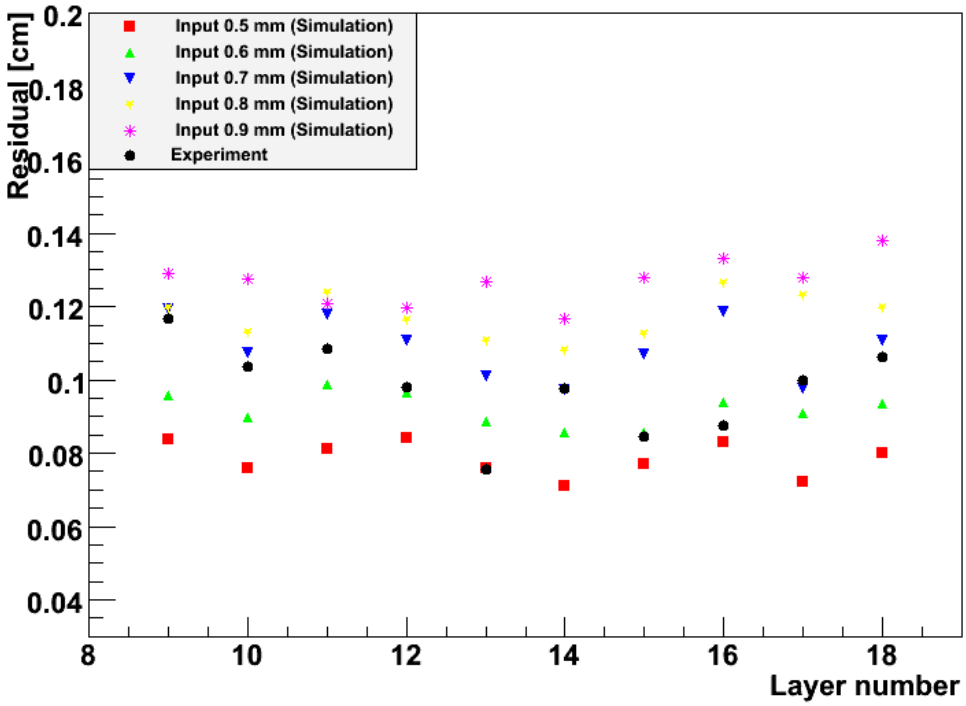


Fig 1: This graph is the residual of each layer number.

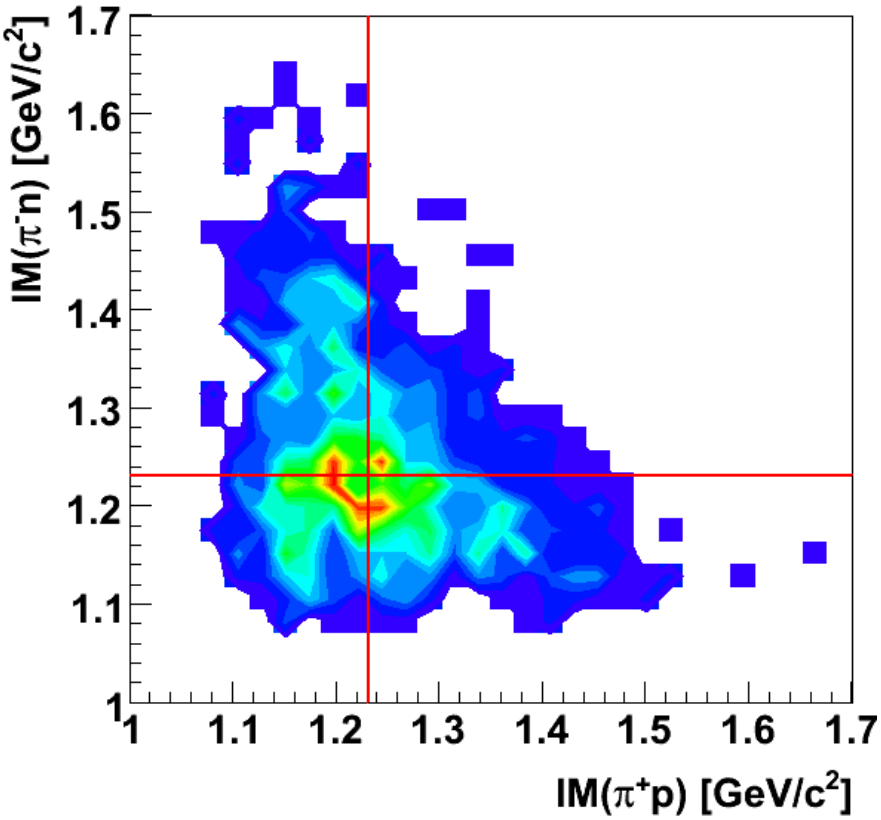


Fig 2 : The invariant mass distribution of π^+p and π^-n. The red line denote delta mass 1232 MeV/c^2.

II. Publications

III. Presentations

1. "Study of double delta photoproduction on the deuteron target", F. Yamamoto, for the NKS2 collaboration, Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University, Kyoto, Japan)
2. "Study of double delta photoproduction on the deuteron target", F. Yamamoto, for the NKS2 collaboration, ELPH Workshop "Double meson production and baryon spectroscopy", (November 29-30, 2012, Research Center for Electron Photon Science, Tohoku University, Sendai, Japan)
3. "Study of double delta photoproduction on the deuteron target", F. Yamamoto, for the NKS2 collaboration, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)

No.23

Name	**Kenji Tsutsumi**
Department	**Physics**
Position	**D2**
Research Title	**RA: Research of electron hole doped high Tc superconductor cupra**

I. Summary of Research

To study the hole-doping effect on spin correlations in *T*'-structured cuprate oxide R_2CuO_4 (*R*: rear earth), we have successfully grown a single crystal of $Pr_{1.9}Ca_{0.1}CuO_4$ as well as powder samples of $Pr_{1.9}Ca_{0.1}CuO_4$ and $Eu_{1.9}Ca_{0.1}CuO_4$. In the all samples, no evidence of shielding signal associated with the superconductivity was observed by magnetic susceptibility measurement. Elastic neutron scattering measurements clarified the existence of long-range magnetic order in the as-grown $Pr_{1.9}Ca_{0.1}CuO_4$. The magnetic ordering temperature was determined to be ~290K, which is consistent with Néel temperature in the mother compound of Pr_2CuO_4. These results suggest a negligible Ca-doping effect on the physical properties in *T*'- R_2CuO_4, which is quite different from the drastic doping evolution of magnetism in *T*-R_2CuO_4.

II. Publications

III. Presentations

1. "Research for Magnetic Excitation of Bi2201-System of Dilution Dope by Pulse Neutron Scattering", K. Tsutsumi, Japan Physical Society 2012 Spring Meeting (March16-19, 2012, Kanseigakuin University, Nishinomiya, Hyogo, Japan)
2. "Static Spin Correlation in $Pr_{2-x}Ca_xCuO_4$ Studied by Neutron Scattering ", K. Tsutusmi, The 19th International Conference on Magnetism , (July 8-13 , 2013, Busan Korea)

3. "Static Spin Correlation in $Pr_{2-x}Ca_xCuO_4$ Studied by Neutron Scattering", K.Tsutsumi , Japan Physical Society 2013 Autumn Meeting (September 18-21, 2013, Yokohama kokuritu University, Japan)
4. "Research for Magnetic Excitation of Bi2201-System of Dilution Dope by Pulse Neutron Scattering", K. Tsutsumi, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan

No.24

Name	**HE Qinghua**
Department	**Physics**
Position	**D2**
Research Title	**RA: Double neutral pion photo-production**

I. Summary of Research

1. In this year, I have been mainly studied double neutral pion photo-production $\gamma p \rightarrow \pi^0\pi^0 p$ in an incident photon beam energy region of 570-1200 MeV. Events corresponding to this reaction channel have been successfully selected. So far, total cross section has been calculated which is consistent with previous data. And the calculation for differential cross section is on the way. I have been also studying some interesting properties for this two identical neutral pion system such as Bose- Einstein correlation(BEC) and Final-States- Interaction (FSI). Some preliminary results have been obtained. I will show these results in the 68th annual meeting of Physical Society of Japan (JPS) which will be held in later March this year(abstract already accepted).
2. In the last year, my work is mainly on two tasks. The first one is the construction of a 4π electro-magnetic calorimeter named BGO-Egg. By the end of last year, 1320 BGO crystals had been successfully installed and BGO-Egg was moved to SPring-8 for the first test. The second one is the study of reaction $\gamma p \rightarrow \pi^0 p$ and $\gamma p \rightarrow \pi^0\pi^0 p$. Among these two channels, the study for the first one has already been finished. The total and cross sections had been successfully obtained and the results shows consistency with previous data, which indicates that our data analysis is reasonable.

II. Publications

III. Presentations

1. "Double neural pion photo-production", Q. He, et al. The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March, 4-6, 2013, Tohoku University, Sendai, Japan)
2. "Double neutral pion photo-production off the proton/deuteron with FOREST at ELPH", Q. He, et al.

Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Japan)

3. “Double neutral pion photo-production”, Q. He, The 6th six department symposium, (February 21 ,2013, Tohoku University, Sendai, Japan)

No.25

Name	**Wen Yin**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Theoretical analysis of high energy hadron scattering using holographic QCD**

I. Summary of Research

1. In this research, I got to know the Soft Wall model as gravity background this year. This model is very similar to the real world QCD phenomenologically. I would like to analyze the high-energy scattering of hadrons using the Soft Wall model in the next fiscal year.
2. Moreover, in addition to this research, I studied the theory in which supersymmetry was broken spontaneously this year. Standard model (SM) which is very much in agreement with the present experiment, however, has some problems. ①There is no candidate of dark matter (DM).②The accuracy of the coupling unification is not so good. ③hierarchy problem etc. The low energy scale Minimum Supersymmetric Standard Model (MSSM) which is known to be a natural extension of SM solves these problems. Supersymmetry is a symmetry which exchange fermion and boson, and also is a natural extension of the translational symmetry which is the symmetry of flat space-time. In order to extend SM supersymmetric, one has to adding the supersymmetric partners to existing particles, So the candidate of DM in ①is contained in this theory. By having increased the kind of particles, the accuracy of unification of the coupling constant of ② becomes good. However, supersymmetry should be broken ,because actual nature does not have supersymmetry. On the other hand, supersymmetry has an effect which cancel the divergence of quantum corrections, and when broken in low energy, it solves the hierarchy problem of ③.

   However, MSSM has additional problems, like CP problem, flavor changing problem ,baryon decay problem etc. In order to solve these problems, it is necessary to specify the process of the breaking down of the supersymmetry in detail. Since inconsistency happens phenomenologically when supersymmetry is broken down in MSSM, supersymmetry must be broken in another sector. The character of MSSM is based on the mediation mechanism of breaking down of the supersymmetry. The mediation mechanism which I studied includes gauge mediation, conformal anomaly mediation, gravity mediation,

and Gravitino mediation.

On the other hand, a scalar particle (here, considered as Higgs particle)with mass of nearly 125GeV was found experimentally in 2012. If MSSM has supersymmetry breaking down with low energy in order to solving the hierarchy problem of ③, 125GeV is too large to have a consistent theory. Therefore, if supersymmetry is believed (and there is some grounds to be believed) , the necessity of throwing away the solution of hierarchy problem will come out. Instead, human principle, i.e. ,the thought that if there is no hierarchy problem, our world is not made and humans are not born, solves the hierarchy problem .Then ,one can consider the supersymmetry theory of high energy scale.

My next purpose of studying is to analyze a general 4-dimensional effective theory in case supersymmetry is broken in rather high energies (10TeV etc.) by the gravity in the extra dimension model, and to make the phenomenological model establish.

II. Publications

III. Presentations

1. "Beyond the standard model: aspects of supersymmetry", Wen Yin. The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March, 4-6, 2013, Tohoku University, Sendai, Japan)

No.26

Name	**Shinichi Kato**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: The study of the reduction of the beam loss for the high-intensity proton accelerator**

I. Summary of Research

In this year, I studied about the reduction of the beam loss for the high-intensity proton accelerator. For the hadron accelerator, the beam intensity is restricted by the value of the beam loss because the beam loss causes the activation. When the activation is too high from a point of the exposure to radiation, we can't maintenance the accelerator. Therefore, the reduction of the beam loss is very important to achieve high-intensity. As the method of the reduction, I attempted suppressing the "incoherent tune spread".

The particles in an accelerator go through while oscillating at a plane which is perpendicular to a travelling direction due to external convergent magnetic field. The number of oscillation of one turn is called "betatron tune". An accelerator has the betatron tune points where the oscillation amplitude increases immediately due to the error or non-linear field. Thus, we commonly determine the betatron

tune by setting the external field so as to avoid such resonance points. However, in the high-intensity accelerator, a repulsive force due to the charge which each particle has (This force is called “space charge force”) decreases the external convergent force. Therefore, the betatron tune of each particle is decreased. Furthermore, the decrement is different for each particle. This phenomenon is called “incoherent tune spread (n_{incoh} spread)”. It causes the beam loss that the betatron tune approaches the resonance points due to n_{incoh} spread. Therefore, we should suppress the ν v_{incoh} spread in order to suppress the beam loss.

I’m studying at the 3GeV rapid cycling synchrotron (RCS) of the Japan Proton Accelerator Research Complex (J-PARC) which is high-intensity proton accelerator. J-PARC comprises a Linac, a RCS, 50GeV synchrotron (MR) and experiment facilities. The 181MeV H^- beams from Linac are injected to the RCS and exchanged to proton by the charge-exchange foil at the injection point. The RCS accelerates those beams up to 3GeV with a period of 20 msec and provides to the MR and the facilities. The beam intensity is 280 kW now. The injection energy will be 400MeV after summer maintenance in 2013 and we are going to try to achieve the beam intensity of 1MW. In the RCS, the beam from Linac is injected to the RCS turn by turn dividing 235 pulses in order to achieve the high-intensity. This injection method is called “multi-turn injection”. During the multi-turn injection, we change the injection beam position and angle depending on time. As a result, the beam which is about thirty times broad compared with Linac beam in the phase space is formed. Thus, the charge density is formed uniform, the space charge force is mitigated and ν_{incoh} spread is suppressed. This injection method is called “Painting Injection”.

However the Painting Injection has been adopted in the RCS, it is expected that the charge density is more formed uniformly and n_{incoh} spread is more suppressed if the time function of the injection beam position and angle during the Painting Injection is modified considering the space charge force. Therefore, I carried out the multi particle simulation considering the space charge force in order to confirm that expectation. As a result, it became cleared that the beam shape which was injected using the present Painting Injection method was different from the shape which we expected from the optical parameters of the Ring in the phase space. Moreover, it became cleared that one of the causes of this difference was the modulation of the optical parameters due to the space charge force. From these result, it was confirmed that we should modify the time function of the Painting Injection conforming to the space charge force effect in order to form more uniform beam.

II. Publications

1. “Effect of injection energy on residual dose around the charge exchange foil”,
   K. Yamamoto, S. Kato, Phys. Rev. ST Accel. Beams 15. 120401 (2012)

III. Presentations

1. “Localization of the Large Angle Foil Scattering Beam Loss Caused by Multi-Turn Charge-Exchange Injection”
   S. Kato, H. Harada, J. Kamiya, M. Kinsho, K. Yamamoto, Y. Yamazaki, M. Yoshimoto, The 3rd

International Particle Accelerator Conference, (May 20-25, 2012, New Orleans, Louisiana, USA)

2. "The Study of the Painting Injection including the Space Charge Effect for the High-Intensity Proton Accelerator"
   S. Kato, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)
3. "Simulation of the Painting Injection including the Space Charge Effect in the J-PARC RCS"
   S. Kato, K. Yamamoto, H. Harada, K. Okabe, M. Kinsho, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.27

Name	**Taku Kikuchi**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Formation of heavy electrons and their ordering in the Anderson lattice model: the continuous-time quantum Monte Carlo study**

I. Summary of Research

1. We have proposed a new ground state for URu_2Si_2 with f^2 crystal field effect scheme. The ground state with the energy scheme Γ_3 - Γ_4 - $\Gamma_1^{(1)}$ can explain the magnetic susceptibility, the elastic constants and the inelastic neutron scattering experimental result.
2. By taking the localized limit of f electrons, The Anderson lattice model becomes the Kondo lattice model where the localized spins couple with conduction electrons. For the analysis, we choose the dynamical mean-field theory in which the lattice system is mapped onto the impurity model. The impurity model is calculated by the continuous-time quantum Monte Carlo method in the Kondo lattice model. We have extended the dynamical mean-field theory combined with the continuous-time quantum Monte Carlo method so as to deal with magnetization in any direction in the antiferromagnetic phase in the Kondo lattice model.
3. By using the above calculation scheme, we can discuss the anisotropy of the susceptibility in antiferromagnetic order. We investigate the temperature dependence of longitudinal and transverse susceptibilities for various Kondo coupling strength. The results are consistent with the experimental data in CeT_2Al_{10} (T=Fe, Ru, Os).

II. Publications

III. Presentations

1. "Dynamical susceptibility for URu2Si2 with f2 crystal field effect scheme. -- Comparison between multipole orders in singlet and doublet models", T. Kikuchi, S. Hoshino, Y. Kuramoto, Japan

Physical Society 2012 Autumn Meeting (September 18-21, 2012, Yokohama National University , Yokohama, Japan)

2. "Anisotropic magnetic response in Kondo lattice with antiferromagnetic order", T. Kikuchi, S. Hoshino, Y. Kuramoto, The 4th workshop on "Formation of heavy electrons and their ordering", (January 12-14, 2013, Tokyo institute of Technology, Tokyo, Japan)
3. "Anisotropic magnetic response in Kondo lattice with antiferromagnetic order", T. Kikuchi, S. Hoshino, Y. Kuramoto, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6-, 2013, Tohoku University, Sendai, Japan)
4. "Heavy-electron antiferromagnetism induced by magnetic field", T. Kikuchi, S. Hoshino, Y. Kuramoto,, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.28

Name	**Hiroki Kobayashi**
Department	**Physics**
Position	**D1**
Research Title	**RA: Neutron Scattering Study on Dual Nature of Itinerant and Localized 4f Electrons in PrCu4Au**

I. Summary of Research

In last year, I performed neutron scattering experiments of $PrCu_4Au$. This experiments reveal antimagnetic characterized by wave vector Q = (1/2 1/2 1/2), but magnetic model has not been decided. In this year, I analyzed neutron diffraction data, I revealed that the type-II ordering model with magnetic moment parallel to [1-10] reproduced the magnetic diffraction pattern. On the other works, I carried out neutron scattering studies of $PrRh_2Zn_{20}$, $PrNb_2Al_{20}$ and $Pr(Fe_{0.9}Co_{0.1})_4P_{12}$.

II. Publications

III. Presentations

1. "Neutron scattering study on *f*-electron states of $PrCu_4Au$", The 19th International Conference on Magnetism (July8-13, 2012, Bexco, Busan, Korea)

No.29

Name	**Yutaro Shoji**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Phenomenology of supersymmetric models with a Peccei-Quinn symmetry.**

I. Summary of Research

At the beginning of this year, I submitted a paper to Journal of High Energy Physics and it was accepted. In the paper, I consider a possibility that the Higgs boson has a component of a light gauge singlet boson and obtains a larger mass, within a Peccei-Quinn invariant extension of the NMSSM. It is important because the Large Hadron Collider recently discovered a Higgs-like boson around 125 GeV and it is slightly heavier than what the minimal model of supersymmetry naturally expects. Considering experimental constraints, I showed there are several allowed regions in which the Higgs mass can be naturally explained. After that, I researched several models that are promising from theoretical or experimental viewpoints, such as supersoft supersymmetry breaking and high scale supersymmetry.

II. Publications

1. “Singlet-doublet Higgs mixing and its implications on the Higgs mass in the PQ-NMSSM”, Kwang Sik Jeong, Yutaro Shoji, Masahiro Yamaguchi, Journal of High Energy Physics, 1209, 007, (2012)

III. Presentations

1. “Peccei-Quinn invariant extension of the NMSSM with Higgs mass around 125GeV ”, Yutaro Shoji, 20th international conference on supersymmetry and unification of fundamental interactions, (August 13-18, 2012, Peking University, Beijing, China)
2. “Peccei-Quinn invariant extension of the NMSSM with a Higgs mass of 125 GeV”, Yutaro Shoji, The 5th GCOE International Symposium on “Weaving Science Web beyond Particle-Matter Hierarchy”, (Mar. 4-6, 2013, Tohoku University, Sendai, Japan

No.30

Name	**Akihiko Sekine**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Theoretical study of electron correlation effect in topological insulators**

I. Summary of Research

In this year, I studied theoretically the electron correlation effect in a Three-dimensional Dirac fermion system which describes a topologically nontrivial state. First, I performed the mean-field approximation in a Dirac fermion system on a cubic lattice with short-range electron-electron interaction between the bulk electrons. It was shown that the topological insulator phase changes to the normal insulator phase with increasing interaction strength. It was also shown that in the region where both electron correlation and spin-orbit coupling are strong, time-reversal and inversion symmetries are spontaneously broken. This phase is considered to be a condensed-matter analog of the corresponding phase in the lattice quantum chromodynamics. [see Ref. 1 in the publication list]

Next I considered a Dirac fermion system on a lattice with 1/r Coulomb interaction between the bulk electrons. This situation is nothing but what is described by the U(1) lattice gauge theory. By performing the strong coupling expansion, it was shown that the topological insulator phase changes to the normal insulator phase in the strong coupling limit, namely the value of the chiral condensate is not zero. It was also shown that this normal insulator phase is stable in the strong coupling region. This behavior is different from that of graphene, a two-dimensional Dirac fermion system. The phase with spontaneously broken time-reversal and inversion symmetries was not found in this model. [see Ref. 2 in the publication list]

II. Publications

1. "*Electron Correlation Induced Spontaneous Symmetry Breaking in a Strongly Spin-Orbit Coupled System*", A. Sekine and K. Nomura, J. Phys. Soc. Jpn. **82** (2013) 033702.
2. "*Strong Coupling Expansion in a Correlated Three-Dimensional Topological Insulator*", A. Sekine and K. Nomura, arXiv:1301:4424 (Submitted).
3. "*Polar Charge Fluctuation and Superconductivity in Organic Conductor*", A. Sekine, J. Nasu, and S. Ishihara, arXiv:1212.4228 (Submitted).

III. Presentations

1. *"Superconductivity in a System with Charge Degree of Freedom Inside of Dimer"*, A. Sekine, J. Nasu, and S. Ishihara, JPS Autumn Meeting (September 18-21, 2012, Yokohama National University, Yokohama, Japan).
2. *"Electron Correlation Induced Spontaneous Symmetry Breaking in a Strongly Spin-Orbit Coupled System"*, A, Sekine and K. Nomura, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan).
3. *"Electron Correlation Effect in a Three-Dimensional Topological Insulator"*, A. Sekine and K. Nomura, JPS Spring Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan).

No.31

Name	**SunChang Choi**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: The roles of excess Fe for magnetic in antiferromagnetic metal Fe1+δSb**

I. Summary of Research

1. We have succeeded in preparing high quality polycrystalline samples of $Fe_{1+\delta}Sb$ (δ=0.40, 0.35, 0.30, 0.25, 0.20) of ~20g and single crystal. We have confirmed that amounts of impurities, mainly Fe, in the samples are negligible (<0.7%) by X-ray diffraction, and M-H measurements.

II. Publications

III. Presentations

1. "Magnetic properties of $Fe_{1+\delta}Sb$", SunChang.Choi, Japan Physical Society 2012 Autumn Meeting (September 18-21, 2012, Yokohama National University , Kanagawa, Japan)
2. "The roles of excess Fe for magnetic in antiferromagnetic metal $Fe_{1+\delta}Sb$", SunChang.Choi, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6-, 2013, Tohoku University, Sendai, Japan)

No.32

Name	**Yusuke Tsuchikawa**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Study of baryon resonance and set up of a new calorimeter BGO EGG at SPring8/LEPS2**

I. Summary of Research

1. I have studied the $\gamma n \rightarrow K^0 \Lambda \rightarrow \pi^0\pi^0 p\pi^- \rightarrow 4\gamma p\pi^-$ reaction with a 4π electromagnetic (EM) calorimeter FOREST, located at Research Center for Electron Photon Science (ELPH), Tohoku University. By means of tightly event selections and kinematical fitting method, a sharply enhanced K^0 peak is observed in the $\pi^0\pi^0$ invariant mass distribution. I am investigating cross sections of this reaction.
2. We set up a new 4π EM calorimeter BGO EGG at SPring-8/LEPS2. The beam line commissioning was done at January 27th 2013. We measured the first Laser Electron Photon (LEP) beam. Using the ADC and TDC information of activated 300 BGO

crystals, LEP beam and carbon target we achieved to confirm a strongly enhanced π^0 peak.

II. Publications

1. "A detailed test of a BSO calorimeter with 100-800MeV positrons",
   T. Ishikawa, Y. Tsuchikawa, et al., Nucl. Insr. and Meth. A **694**, 348 (2012)
2. "Λ photoproduction studied with an electromagnetic calorimeter FOREST",
   Y. Tsuchikawa et al., PoS(QNP2012)100

III. Presentations

1. "Λ photoproduction studied with an electromagnetic calorimeter FOREST",
   Y. Tsuchikawa for the FOREST collaboration, QNP2012 (6th International Conference devoted to Quark Nuclear Physics) (Spring 16-19, 2012, Paris Polytechnique University, Palaiseau, France)
2. "The $\gamma n \rightarrow K^0\Lambda$ reaction studied with an electromagnetic calorimeter FOREST",
   Y. Tsuchikawa for the FOREST collaboration, The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)
3. "The $\gamma n \rightarrow K^0\Lambda$ reaction studied with an electromagnetic calorimeter FOREST",
   Y. Tsuchikawa for the FOREST collaboration, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Japan)

No.33

Name	**Tomohiro Hayamizu**
Department	**Physics**
Position	**D1**
Research Title	**RA: Development of laser-cooled Fr atom source for the electron Electric Dipole Moment search** **Initiative A: Storage source development for laser-cooled Fr atom toward to the electron EDM search**

I. Summary of Research

In this year, I did research on development of experimental instruments for the electron Electric Dipole Moment search using radioactive Francium (Fr) atoms in an optical trap. It is necessary to develop a high-intensity and laser-cooled Fr atom source for the highest precision measurement. Toward to supply enough number of Fr to the optical trap, I have built a laser-cooled Fr source at Cyclotron and Radioisotope Center (CYRIC), Tohoku University (see Fig.1). This instrument is composed of an Fr ion source, 10m long Fr ion beam line, an ion to atom converter, transverse and longitudinal laser cooling

(Zeeman slower) and a magneto-optical trap. In this year, I built an Fr ion beam line from the production ion source to the ion to atom converter. In online experiment, I succeeded to produce ^{210,211}Fr and recorded ours best of 1×10^{6} particle/sec as the maximum extraction yield from the Fr ion source. I also transported Fr to the end of the beam line. I also worked to improve transmission efficiency from the ion source to the ion-to atom converter using Rb ion beam. Therefore I will conduct the experiment of trapping much number of Fr atoms in the magneto-optical trap.

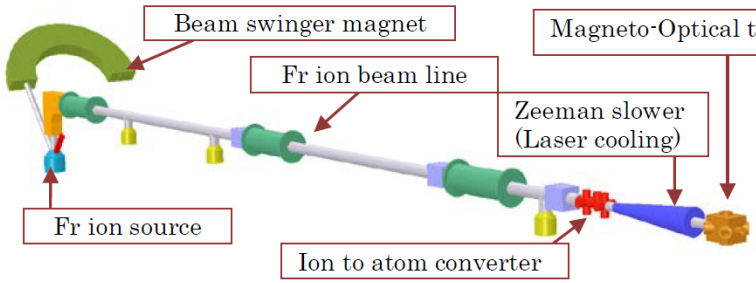


Fig.1: a design of the laser-cooled Fr atom source.

II. Publications

1. "Search for permanent EDM using laser cooled Fr atoms", Hirokazu Kawamura, T. Aoki, H. Arikawa, S. Ezure, T. Furukawa, K. Harada, A. Hatakeyama, K. Hatanaka, T. Hayamizu, K. Imai, T. Inoue, T. Ishikawa, M. Itoh, T. Kato, T. Murakami, H.S. Nataraj, T. Sato, Y. Shimizu, T. Wakasa, H.P. Yoshida and Y. Sakemi, in press Hyperfine Interact

III. Presentations

1. "Development of Fr ion source with melting Au target for electron EDM search", T. Hayamizu et al., Jul. 23-27, 2012, The 23rd International Conference on Atomic Physics (ICAP2012), Ecole Polytechnique, Palaiseau, France
2. "Development of laser-cooled Fr atom source for the electron Electric Dipole Moment search" T. Hayamizu, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", Mar. 4-6, 2013, Tohoku University, Sendai, Japan

No.34

Name	**Stephane Yu Matsushita**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: The surface plasmon of metal nanoclusters grown on the hydrogen-terminated Si(111)-(1×1) and Si(110)- (1×1) surfaces**

I. Summary of Research

In this year, I studied a surface plasmon of Ag nano-cluster on hydrogen-terminated Si(111)-(1×1) surface by means of high-resolution electron energy loss spectroscopy (HREELS). The peak of surface plasmon at the G point was found at 3.86 eV, which was higher than that of single crystal Ag(111) surface. In the region below 0.3 $Å^{-1}$, the energy dispersion was positive, i.e., the peak showed a blue shift as a function of the parallel momentum. At the momentum higher than 0.3 $Å^{-1}$, however, the dispersion curve suddenly changed to a negative slope. Such kind of dispersion curve is never reported nether theoretically nor experimentally.

Furthermore, I found several lose peaks in a low (0.5 ~ 2.2 eV) and high (7 ~ 9 eV) energy region. There were four peaks in the low-energy region. The peak in a high energy region was observed only in a large parallel momentum (over 0.6 $Å^{-1}$) and had a broad width (full width of half maximum) compared to the other loss peaks. The peak in the low-energy region was reported in a study of electron excitation of Au nano-cluster, and the peak in high-energy region were observed at a few experiments of Ag thin film, but so far, there is no detailed discussion of these phenomenon.

As for now, I evaluate the possible association of quantum effects, which depends on the cluster shape, to the existence of such loss peak.

II. Publications

1. “Preparation of clean and well-ordered hydrogen-terminated Si(110)-(1×1) surfaces and the measurements of vibrational modes”, S. Suto, K. Matsui, S.Y. Matsushita, H. Kato, H. Nakaya, T. Taoka, A. Kasuya, T. Yamada, Appl. Surf. Sci. (2013) in press.

III. Presentations

1. “Surface phonon dispersion with a glide plane on H:Si(110)-(1×1) surface”, S.Y. Matsushita, K. Matsui, H. Kato, T. Yamada, S. Suto, Surface Science Society of Japan the 32nd Meeting (November 20-22, 2012, Tohoku University, Sendai, Japan)
2. “Surface phonon dispersion on the hydrogen-terminated Si(110)-(1×1) surface”, S.Y. Matsushita, The 5th International GCOE symposium on “Weaving Science Web beyond Particle-Matter Hierarchy”, (March 4-6, 2013, Tohoku University, Sendai, Japan)
3. “Energy dispersion of surface plasmon of Ag nanocluster on H:Si(111)-(1×1) surface”, S.Y. Matsushita, H. Kato, E. Kawamoto, T. Yamada, S. Suto, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Japan)

No.35

Name **Hisayoshi Muraki**

Department **Physics**

Position **D1**

Research Title **RA/Initiative A: On analysis of string in curved space-time**

I. Summary of Research

In this year, I studied the motion of a string in the curved space-time background, especially focusing on the H-flux background, which has to be introduced when the space-time is curved. And I studied the low energy effective theory as well, which is obtained from the analysis of the string's motion. Investigating the low energy effective theory might suggest geometric picture of the quantum gravity.

Concretely, I investigated the description of the effective theory with H-flux using some kind of "star-product". The star-product is closely related to the non-commutative space, the deformation quantization on the manifold and so on. So that the product's property might suggest some geometric information on the space, where it is defined on. In the ordinary case, the star-product is not commutative but associative. However, the "star-product" obtained from string theoretical analysis is both non-commutative and non-associative. Until now its geometrical interpretation has not been clear.

In my study, as an approach to give some insight, I attempted to investigate its property from the algebraic point of view, and found that the non-associative "star-product" can be controlled in terms of the so-called quasi-Hopf algebra, and discussed its symmetry.

II. Publications

III. Presentations

1. "Hopf algebraic symmetry of effective theory of string in H-flux background",
   H. Muraki, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan
2. "Hopf algebraic symmetry of effective theory of string in H-flux background",
   H. Muraki, KEK Theory Workshop 2013 (March 18-21, 2013, KEK, Tsukuba, Japan)
3. "Hopf algebraic symmetry of effective theory of string in H-flux background",
   T. Asakawa, H. Muraki and S. Watamura, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.36

Name	**Kenkoh Sugihara**
Department	**Physics**
Position	**D1**
Research Title	**Initiative A: Research for rheology of block copolymer droplet many-body system**

I. Summary of Research

Block copolymer is a polymer in which chemically different subchains are combined together. Because of the difference in the chemical aspects of each subchain, block copolymers show several typical phases, such as lamellar, cylinder and gyroid phases. Recently (in 2010) it has been experimentally confirmed that block copolymers take a form of droplets in a solvent. Rheological behavior of such a system is not only a target of extensive studies in the field of statistical physics but also a useful candidate of applications in the industrial sciences.

As the length scale of the domains of block copolymers is usually of the order of hundreds nano-meters, which is much larger than the atomic scale but still smaller than the continuum length scale, such length scales are called meso-scale. This length scale corresponds to the intermediate regime between the typical length scale of the field theory and that of the particle description. As a result, it is useful to introduce a hybrid approach between the continuous mean field theory and the particle model in order to describe the statics and dynamics of many interacting droplets in a solvent.

In order to find out an efficient method for simulating above system, we did the folowing:

1. Construction of a software for the self-consistent field simulation of a single droplet.
2. Optimization of the performance of the simulation software.
3. Construction of the hybrid system model that can efficiently simulate the whole system composed of the droplets and the solvent (under construction).

II. Publications

III. Presentations

1. Research for rheology of block copolymer droplet many-body system, K.Sugihara, GCOE annual conference (March 5, 2013, Tohoku Univ., Sendai, Japan)

No.37

Name	**Yu Murao**
Department	**Physics**
Position	**D3**
Research Title	**Initiative A: Impurity effect on dislocation dynamics in Ge**

I. Summary of Research

We investigated the following theme:

1. Growth of Ge crystal highly-doped with Sn impurity
2. Doping effects for dislocation motion
3. Mechanism of dislocation locking by impurities

II. Publications

1. "Growth of dilute GeSn alloys", Y Murao, T. Taishi, K. Kutsukake, Y. Tokumoto, Y. Ohno and I. Yonenaga,: Proc. 7th Int. Workshop on Modeling of Crystal Growth (IWMCG-7), 130-131, (2012)
2. "Czochralski growth techniques of germanium crystals grown from a melt covered partially or fully by liquid B2O3", T. Taishi, Y. Hashimoto, H. Ise, Y. Murao, T. Ohsawa, and I. Yonenaga,: J. Crystal Growth 360, 47-51, (2012)
3. "Oxygen in Ge crystals grown by the B2O3 encapsulated Czochralski method", I. Yonenaga, T. Taishi, H. Ise, Y. Murao, K. Inoue, T. Ohsawa, Y. Tokumoto, Y. Ohno, Y. Hashimoto,: Physica B 407, 2932-2934, (2012)

III. Presentations

1. "Effects of O impurity on dislocation activity in Ge", Y. Murao, T. Taishi, Y. Tokumoto, K. Kutsukake, Y. Ohno, and I. Yonenaga; Summit of Material Science 2012, (Nov. 27-31, 2012, IMR, Tohoku University, Sendai, Japan)
2. "Growth of Dilute GeSn alloys", Y. Murao, T. Taishi, K. Kutsukake, Y. Tokumoto, Y. Ohno, and I. Yonenaga; The 7th International Workshop on Modeling in Crystal Growth, (Oct. 28-31, 2012, Grand Hotel, Taipei, Taiwan)
3. "Aging effect on dislocation locking by O impurity in Ge", Y. Murao, T. Taishi, Y. Tokumoto, K. Kutsukake, Y. Ohno, and I. Yonenaga; Japan Physical Society 2012 Autumn Meeting (Sep. 18-21, 2012, Yokohama National University, Japan)

No.38

Name	**Huynh Kim Khuong**
Department	**Physics**
Position	**D2**
Research Title	**Initiative A: Impurity effects on Dirac cone states of $Ba(FeAs)_2$**

I. Summary of Research

1. Synthesized high quality crystals of $Ba(FeAs)_2$
2. Measured electrical transport properties of $Ba(FeAs)_2$ single crystal under high magnetic fields (up

to 50 Tesla).

3. Analyzed the datasets obtained from the meausurements. Derived important information from the analyses.

II. Publications

1. "Both electron and hole Dirac cone states in $Ba(FeAs)_2$ confirmed by magnetoresistance", Khuong K. Huynh, Yoichi Tanabe, Katsumi Tanigaki, Physical Review Letters, 106, 217004, (2011)
2. "Coexistence of Dirac-cone states and superconductivity in iron pnictide $Ba(Fe_{1-x}Ru_xAs)_2$ ", . Y. Tanabe, K. K. Huynh, T. Urata, S. Heguri, G. Mu, J. T. Xu, R. Nouchi, N. Mitoma, K. Tanigaki, Physical Review B, 84, 100508, (2011)
3. "Suppression of backward scattering of Dirac fermions in iron pnictides $Ba(Fe_{1-x}Ru_xAs)_2$ ", Y. Tanabe, K. K. Huynh, T. Urata, S. Heguri, G. Mu, J. T. Xu, R. Nouchi, T. Tanigaki, Physical Review B, 86, 094510, (2012)

III. Presentations

1. "Magneto-electrical transport of annealed $Ba(FeAs)_2$ single crystals", K. K. Huynh, Y. Tanabe, T. Urata, S. Heguri, K. Tanigaki, T. Kida, M. Hagiwara, Japan Physical Society 2012 Autumn Meeting (September 19th, 2012, Yokohama University , Yokohama, Japan)
2. "Five-carrier type analysis of transort properties of $Ba(FeAs)_2$", K. K. Huynh, Y. Tanabe, T. Urata, S. Heguri, K. Tanigaki, T. Kida, M. Hagiwara, M2S conference, (July 29th – August 3rd Washington DC, USA)

No.39

Name	**Benda XU**
Department	**Physics**
Position	**D2**
Research Title	**Initiative A: Observation of 7Be Solar Neutrinos with KamLAND**

I. Summary of Research

1. ^{85}Kr measurement with MoGURA

   ^{85}Kr measurement by MoGURA rollback trigger has been tested and discussed. This measurement will give an upper limit to ^{85}Kr concentration in KamLAND, which is highly correlated to ^{7}Be solar neutrino flux. Taking data for half a year will improve KamLAND ^{7}Be solar neutrino result by 2% uncertainty. This result has been reported in JPS autumn 2012 meeting.

   Furthermore, analyzing of ^{85}Kr concentration with a soft rollback trigger on KamLAND old

electronics, FBE, proves the claim of the performance. This result will be presented in GCOE international symposium 2013, KamLAND collaboration meeting in spring of 2013, and JPS spring 2013 meeting.

2. Low energy simulation with KLG4sim

   KLG4sim is a set of simulation tools for KamLAND based on Geant4. The auther has ported KLG4sim from Geant4.9.3 to Geant4.9.5. However because of the EM model change in Geant4.9.5, KLG4sim has to be tuned to give correct result. This work is still underway.

   The author has also developed a low energy model based on Poisson distribution, independent of KLG4sim. This simple model helps to understand KamLAND energy response and describes low energy spectra very well. This model will be applied to the global ^{7}Be solar neutrino flux fit and proved to be superior to Gaussian model widely used before.

3. Vertex Fitter Tuning

   The author has tuned vertex fitter in KamLAND, called v2, towards the detector response after purification. The vertex bias has been improved from 6cm to 3cm, and it will be integrated to KamLAND analysis toolkit. The priciple of v2 fitter will be documented and included in KamLAND full reactor paper. It will be reported in KamLAND collaboration meeting in spring 2013.

II. Publications

1. “Limits on Majoron-emitting double-beta decays of Xe-136 in the KamLAND-Zen experiment”, KamLAND-Zen collaboration, Phys.Rev.C86:021601,2012
2. “Limit on Neutrinoless ββ Decay of Xe-136 from the First Phase of KamLAND-Zen and Comparison with the Positive Claim in Ge-76 ”, arXiv:1211.3863[nucl-ex]

III. Presentations

1. “DAQ Upgrade in KamLAND”, XU Benda, neutrino 2012 (6/3-9 , 2012, Kyoto, Japan)
2. “Towards Measurement of ^{85}Kr by MoGURA”, Benda Xu, Japan Physical Society 2012 Autumn Meeting (September 11-14, 2012, Kyoto Sangyo University , Kyoto, Japan)
3. “MoGURA DAQ System at KamLAND”, Benda Xu, Open-It Workshop (November 26-29, 2012, Zao Yamagata, Japan)
4. “Analysis of ^{85}Kr concentration in KamLAND with rollback technique”, Benda Xu, The 5th International GCOE symposium on “Weaving Science Web beyond Particle-Matter Hierarchy”, (March 4-6-, 2013, Tohoku University, Sendai, Japan)
5. “Measurement of ^{85}Kr Contamination in KamLAND (II)”, Benda Xu, Japan Physical Society 2013 Spring Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.40

Name **Yusuke Yamada**

Department **Physics**

Position **D1**

Research Title **Initiative A: Study of electrical characteristics of conducting polymers by broadband THz**

I. Summary of Research

Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate)(PEDOT:PSS) is one of the most successful conducting polymers because of its stable high conductivity and water solubility. The dc conductivity of PEDOT:PSS can be significantly increased by the addition of organic solvents such as ethylene glycol (EG). However, its mechanism of carrier transport is still poorly understood. In this study, we performed following experiment and analysis, focusing attention on the EG addition effect.

1. We prepared PEDOT:PSS films by spin coating the aqueous solution (2.6%) with EG concentration 0% and 15% on silicon substrate.
2. We measured the temperature dependence of THz optical conductivity from 10 K to 300 K and measured IR-UV reflectance spectrum using conventional FTIR spectrometer (12-250 THz) and IR-Vis-UV spectrometer (115-1000 THz) at room temperature of PEDOT:PSS films. In addition, we measured temperature dependence of IR transmission spectra from 100 K to 300 K.
3. We analyzed the results using Localization-modified Drude (LD) model.

The frequency dependence of THz optical conductivities was well explained by the LD model at higher temperature region, which describes the electrical conduction of the weak localized carrier state. Temperature dependence of IR transmission spectra was also explained by the LD model for both samples. On the other hands, THz optical conductivity deviates from the LD model at lower temperature for both samples.

II. Publications

III. Presentations

1. “Colloidal Particle Size Dependence of Carrier Transport in PEDOT:PSS films Studied by THz-IR-UV spectroscopy”, Yusuke Yamada, Masatsugu Yamashita, Takahiko Sasaki, Hidenori Okuzaki, Chiko Otani, The Japan Society of Applied Physics Spring Meeting 2012 (March 15-18, 2012, Waseda University, Tokyo, Japan)
2. “Carrier transport in conducting polymer PEDOT:PSS thin films studied by terahertz and infrared spectroscopy”, Y. Yamada, M. Yamashita, T. Sasaki, H. Okuzaki, C. Otani, OPTICS and PHOTONICS international Congress 2012, (Thursday, April 26, 2012, Yokohama, Japan)
3. “Temperature dependence of THz conductivity of conductive polymer PEDOT:PSS investigated by

THz time domain spectroscopy" Yusuke Yamada, Masatsugu Yamashita, Takahiko Sasaki, Hidenori Okuzaki, Chiko Otani, The Japan Society of Applied Physics Spring Meeting 2012 (September 11-14, 2012, Ehime University and Matsuyama University, Matsuyama, Japan)

4. "Temperature Dependence of Conductivity of PEDOT:PSS in Terahertz Region", Yusuke Yamada, Masatsugu Yamashita, Takahiko Sasaki, Hidenori Okuzaki, Chiko Otani, IRMMW-THz 2012, (September 23-28,2012, Wollongong, Australia)
5. "Solvent effect on temperature dependence of Terahertz conductivity in conducting polymer PEDOT:PSS thin film", Y. Yamada, M. Yamashita, T. Sasaki, H. Okuzaki, C. Otani, International Symposium on Frontiers in THz Technology FTT 2012 (November 27-29, 2012, Nara, Japan)
6. "Carrier transport in conducting polymer PEDOT:PSS thin films studied by temperature dependence of THz and infrared spectroscopy" Y. Yamada, M. Yamashita, T. Sasaki, H. Okuzaki, C. Otani, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.41

Name	**A.M. Haidar**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Spin Pumping in High Tc Superconductor La1.85Sr0.15CuO4 thin films**

I. Summary of Research

1. Introduction:

The field of spintronics, a prospering class of efficient spin-based magnetic memories and computing devices, has recently attracted great interest throughout the last decade. Generation and detection of spin currents in solid-state systems are the fundamental part in the field of spintronics [1]. One method for generating and detecting spin currents is the combination of the spin pumping [2] and the inverse Spin-Hall effect (ISHE) [3]. The spin pumping enables spin-current generation from magnetization precession motion at a ferromagnetic/paramagnetic interface; a precessing magnetization in the ferromagnetic layer induces a pure spin current in the attached paramagnetic layer. This spin current is converted into a charge current via the spin-orbit interaction, i.e. the ISHE, in the paramagnetic layer and allows the electric detection of spin current. The combination of the spin pumping and the ISHE allows quantitative measurements of spin currents [4].

Up to now, the spin pumping has been investigated in magnetic metal/paramagnetic metal films. However, there are not sufficient reports on the magnetic metal/oxide material system. The ultimate purpose of present research is to study the behavior of spin wave spin current in high T_c superconductor

$La_{1.85}Sr_{0.15}CuO_4$ (LSCO). The reason for choosing LSCO is, it has both metallic phase and pseudogap phase or spin-gap phase. However in present study, the spin pumping has been studied on LSCO attached to $Ni_{81}Fe_{19}$ (Permalloy or Py) as ferromagnet at room temperature.

2. Method:

The thin film of LSCO has been prepared on $SrLaAlO_4$ (SLAO) substrate at (001) direction (i.e. CuO_2 plane is parallel to substrate) by Pulsed Laser Deposition (PLD). The first hurdle of present research was to find out suitable parameters for deposition. Thin film of LSCO Single crystal has been successfully deposited at the following conditions, deposition temperature = 775℃, frequency = 4Hz, pressure = 1.2×10^{-1} Torr and post deposition annealing = 1hour at 400℃ & 400 Torr. After LSCO deposition, 10nm of Py was evaporated at high vacuum ($\sim5\times10^{-7}$ Torr) and spin pumping was carried out by Electron Spin Resonance (ESR) system.

3. Result:

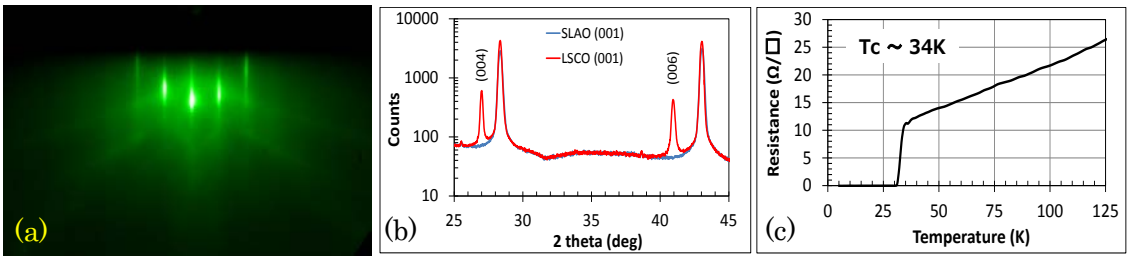


Fig.1: (a) RHEED pattern of ~110nm thick LSCO single crystal at (001) direction, (b) XRD analysis of LSCO, (c) Superconducting transition temperature of LSCO.

Figure 1 shows the crystal quality of LSCO thin film. The parallel stripe of RHEED pattern and XRD analysis confirms that the LSCO had single crystal growth. The superconducting transition temperature at 34K confirms that the composition of LSCO was stable.

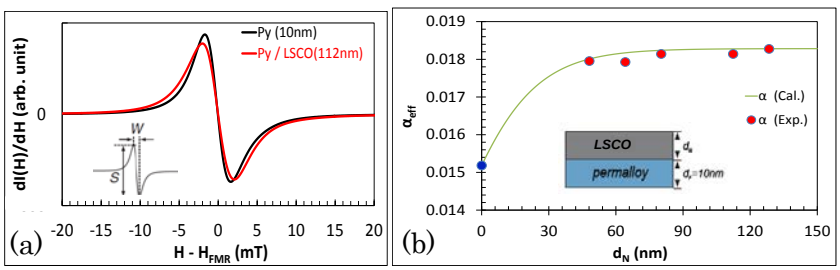


Fig.2: (a) FMR signal of Py/LSCO bilayer, (b) Thickness dependence of Gilbart damping constant.

Figure 2(a) shows the field dependence of FMR signal for Py/LSCO bilayer where I denotes the intensity of microwave absorption. The increase of spectral width, W, shows the spin injection in Py/LSCO bilayer. The damping constant is measured from the spectral width using the equations from reference [5] and is

calculated using reference [6]. From these results, the Gilbart damping constant, mixing conductance and spin diffusion length are predicted as ~0.018, ~5×10^{12}(m^{-2}) and ~35nm. These parameters will be necessary to determine the spin current density and spin Hall angle at Py/LSCO system. In future, spin pumping on thinner LSCO film (less than ~35nm), and details analysis of spin current in Py/LSCO bilayer system will be carried on.

Referrence

1) S. Maekawa, Concepts in Spin Electronics (Oxford University Press, Oxford, 2006).

2) Y. Tserkovnyak et al., Rev. Mod. Phys. ***77****, 1375 (2005).*

3) S. O. Valenzuela et al., Nature (London) ***442****, 176 (2006).*

4) E. Saitoh et al., Appl. Phys. Lett. ***88****, 182509 (2006).*

5) Y. Ando et al., Appl. Phys. ***109****, 103913 (2011).*

6) H. Nakayama et al., Phys. Rev. B ***85****, 144408 (2012)*

II. Publications

III. Presentations

1. "Spin Pumping in High T_c Superconductor $La_{1.85}Sr_{0.15}CuO_4$ thin films",
   S. M. Haidar, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.42

Name	**Kentaro Negishi**
Department	**Physics**
Position	**D2**
Research Title	**RA: Study of the decay $B^0\to DK^{*0}$ for ϕ_3 measurement**

I. Summary of Research

1. In this year, I studied the decay $B^0\to DK^{*0}$ followed by $D\to K_S\pi^+\pi^-$, where D indicates D^0 or anti-D^0. We reconstruct the $DK^+\pi^-$ state in a phase space corresponding to $DK^*(892)^0$. The CP violating angle ϕ_3 affects decay rates on D three body decay Dalitz plane via the interference between b→u and b→c transitions. ϕ_3 is one of the angle of unitary triangle. This study is important for validation of the standard model. This study is first result of ϕ_3 measurement in neutral B, if we can measure ϕ_3 value. It is important in the way of cross check with ϕ_3 from charged B. Our target is first model-independent Dalitz method in neutral B. This method require flavor D strong phase. Those values are refered from charm factory for example CLEO data. In near

future, next C and B factory era, this method will be evaluated

II. Publications

III. Presentations

1. "Study of the decay $B^0 \to DK^{*0}$ for ϕ_3 measurement", Kentaro Negishi, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.43

Name	**Wenjing Min**
Department	**Physics**
Position	**D1**
Research Title	**RA/Initiative A: Photo-induced cooperative phenomena in correlated electron system**

I. Summary of Research

1. Read a review about "Photo－induced Phase Transitions" both in experimental and theoretical research. Well acquainted with the up-to-date research progress about this area.
2. Determined the specific research theme――photo-induced superconductivity and partly reviewed the work――Resonant generation of coherent phonons in a superconductor by ultrafast optical pump pulses. Mastered the basic knowledge of superconductivity and linear response theory.
3. Began the learning of new calculation and computer program coding techniques――Green's function method and C++.
4. Began the research of photo－induced superconductivity including the CDW/SDW in the model.

II. Publications

III. Presentations

1. "Polaron dynamics properties with magnetic impurity in conjugated polymers", Wenjing. Min, The 5th GCOE International Symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (Mar. 4-6, 2013, Tohoku University, Sendai, Japan)

No.44

Name	**Thomas James Kleeman**
Department	**Physics**
Position	**D1**
Research Title	**RA /Initiative A: Bilayer Graphene Intercalation Compounds Studied by Angle-Resolved Photoemission Spectroscopy**

I. Summary of Research

In 2012, to elucidate the band structure of thinnest limit of graphite intercalation compounds (GICs), I have performed angle-resolved photoemission spectroscopy (ARPES) on C_8RbC_8 and C_8KC_8. Using angle-resolved photoemission spectroscopy (ARPES), it was possible to capture the full band structure of these compounds. Both exhibit a shift due to the doping effect from the intercalant atoms, in addition to band folding characteristic due to the creation of the 2x2 metal superstructure. We also measured the "interlayer band" in C_8RbC_8. This band is believed to be critical to superconductivity in bulk GICs, and its observation in these thin-layer materials points to the possibility of superconductivity. LEED study was also performed to examine the phase transition of C_8RbC_8 at temperatures between 80K and 300K.

I have also begun work on C_8CsC_8. This compound will complete the study of the alkali series of bilayer intercalation compounds, allowing for a more complete element-dependent analysis of these materials. So far, LEED results appear promising, although it has not been possible thus far to capture data using ARPES. More work will be necessary to refine the synthesis procedure of this material and obtain high quality data.

II. Publications

III. Presentations

1. "High Resolution ARPES Study of C8AC8 (A=K,Rb)", J. Kleeman, Japan Physical Society 2012 Autumn Meeting (September 18-21, 2012, Yokohama National University , Yokohama, Japan)
2. "High-resolution ARPES studies of C8AC8 (A =K and Rb)", J. Kleeman, International Conference on Emerging Advanced Nanomaterials (October 21-26, 2012, Brisbane, Australia)
3. "Electronic structure of graphene intercalation compounds studied by ARPES", J. Kleeman, Joint Symposium with 6 Departments of Tohoku University (February 21, 2013, Tohoku University, Sendai, Japan)
4. "Electronic structure of Rb intercalated bilayer graphene", The 5th International GCOE symposium on "Weaving Science Web beyond Particle-Matter Hierarchy", (March 4-6, 2013, Tohoku University, Sendai, Japan)
5. "Rb-intercalated bilayer graphene studied by high-resolution ARPES", J. Kleeman, American Physical Society March Meeting (March 18-22, 2013, Baltimore, United Stated of America)
6. "ARPES study of alkali-doped bilayer graphene", J. Kleeman, Japan Physical Society 2013 Spring

Meeting (March 26-29, 2013, Hiroshima University, Hiroshima, Japan)

No.45

Name	**Hui SHANG**
Department	**Physics**
Position	**D1**
Research Title	**Initiative A: Realization of electrically pumped organic semiconductor laser with field effect transistor structure**

I. Summary of Research

1. Firstly solved a pendent problem of why some organic crystals have dual gain narrowing peaks which is a crucial factor for realizing electrically driven organic laser. Now the draft of this work has been accomplished.
2. Set up the facilities of laser pump for observing exciton behavior at the interface of bilayer single crystals.

II. Publications

1. "Large Organic Single Crystal sheets Grown from the Gas-Liquid and Gas-Liquid-Solid Interface", Hui Shang, Huan Wang, Na Gao, Fangzhong Shen, Xianjie Li, Yuguang Ma,* *CrystEngComm* (The Royal Society of Chemistry), **14**, 869-874, 2012.

III. Presentations

International Conference

1. "Optoelectronic Properties of Newly Synthesized Furan/Phenylene Co-oligomer Single Crystal", Hui Shang, Susumu Ikeda, Kanagasekaran Thangavel, Hidekazu Shimotani, Kazuaki Oniwa, Tienan Jin, Uzzaman Md. Akhtar, Naoki Asao, Yoshinori Yamamoto, Hiroyuki Tamura, Ikutaro Hamada, Katsumi Tanigaki, MRS Spring Meeting, Z7. 25, San Francisco, USA, Apr. 2012. (Poster)
2. "Investigation on Gain Properties of Organic Single Crystals towards Electrically Driven Lasers", Hui Shang, Susumu Ikeda, Kanagasekaran Thangavel, Hidekazu Shimotani, Kazuaki Oniwa, Tienan Jin, Naoki Asao, Yoshinori Yamamoto, Hiroyuki Tamura, Ikutaro Hamada, Kenta Abe, Masayuki Yoshizawa, Katsumi Tanigaki, OIST International Symposium on Organic Electronics, OP-7, Okinawa, Japan, Oct. 2012. (Poster)

Conference in Japan

3. "Optoelectronic Properties of Newly Synthesized Furan/Phenylene Co-oligomer Single Crystal", Hui Shang, Susumu Ikeda, Kanagasekaran Thangavel, Hidekazu Shimotani, Kazuaki Oniwa, Tienan Jin, Uzzaman Md. Akhtar, Naoki Asao, Yoshinori Yamamoto, Hiroyuki Tamura, Ikutaro Hamada,

Katsumi Tanigaki, , JPS Spring Meeting, 24aCF-5, Kwansei Gakuin University, Japan, Mar. 2012. (Oral)

4. "Air stable organic ambipolar field effect transistor with gold electrodes", Kanagasekaran Thangavel, Susumu Ikeda, Hui Shang, Ryotaro Kumashiro, Hidekazu Shimotani, Katsumi Tanigaki, JPS Spring Meeting, 24pCF-5, Kwansei Gakuin University, Japan, Mar. 2012. (Oral)
5. "Amplified Spontaneous Emission in Newly Synthesized Furan/Phenylene Co-oligomer Single Crystal", Hui Shang, Susumu Ikeda, Kanagasekaran Thangavel, Hidekazu Shimotani, Kazuaki Oniwa, Tienan Jin, Naoki Asao, Yoshinori Yamamoto, Hiroyuki Tamura, Ikutaro Hamada, Kenta Abe, Masayuki Yoshizawa, Katsumi Tanigaki, JPS Fall Meeting, 20pHA-8, Yokohama National University, Japan, Sep. 2012. (Oral)
6. "Ambipolar organic light emitting field effect transistors ", Kanagasekaran Thangavel, Hui Shang, Susumu Ikeda, Ryotaro Kumashiro, Hidekazu Shimotani, Katsumi Tanigaki, JPS Fall Meeting, 20pHA-9, Yokohama National University, Japan, Sep. 2012. (Oral),