Publications

Division of New Materials Science

Takigawa group

We have been performing nuclear magnetic resonance experiments on various quantum spin systems and strongly correlated electron systems to explore novel quantum phases with exotic ordering and fluctuation phenomena. The major achievements in the year 2013 include: (1) Investigation by ^{7}Li-NMR of the magnetic phase transition in the frustrated antiferromagnets $LiInCr_4O_8$ and $LiGaCr_4O_8$ with the novel breathing pyrochlore structure, (2) Microscopic examination of the quantum critical and non-fermi liquid behavior in the valence fluctuating Yb compound alpha- and beta- $YbAlB_4$, (3) Continued investigation of the magnetic and structural transition in single crystals of volborthite with the distorted Kagome lattice aimed at the full understanding of the phase diagram in magnetic field.

1. †Anisotropic spin fluctuations in the quasi one-dimensional frustrated magnet $LiCuVO_4$: K. Nawa, M. Takigawa, M. Yoshida and K. Yoshimura, J. Phys. Soc. Jpn. **86** (2013) 094709(1-13).
2. *Magnetic Order in the Spin-1/2 Kagome Antiferromagnet Vesignieite: M. Yoshida, Y. Okamoto, M. Takigawa and Z. Hiroi, J. Phys. Soc. Jpn. **82** (2013) 013702(1-5).
3. *Incomplete Devil`s Staircase in the Magnetization Curve of $SrCu_2(BO_3)_2$: M. Takigawa, M. Horvatic, T. Waki, S. Kramer, C. Berthier, F. L. Bertrand, I. Sheikin, H. Kageyama, Y. Ueda and F. Mila, Phys. Rev. Lett. **110** (2013) 067210(1-5).
4. Iterative deconvolution of quadrupole split NMR spectra: F. Mila and M. Takigawa, Eur. Phys. J. B **86** (2013) 354(1-4).
5. †*Field-induced incommensurate phase in the strong-rung spin ladder with ferromagnetic legs: H. Yamaguchi, H. Miyagai, M. Yoshida, M. Takigawa, K. Iwase, T. Ono, N. Kase, K. Araki, S. Kittaka, T. Sakakibara, T. Shimokawa, T. Okubo, K. Okunishi, A. Matsuo and Y. Hosokoshi, Phys. Rev. B **89** (2014) 220402.

Sakakibara group

We study magnetism and superconductivity of materials having low characteristic temperatures. These include heavy-electron systems, quantum spin systems and frustrated spin systems. The followings are some selected achievements in the fiscal year 2013. (1) Field and temperature variations of the specific heat C(H,T) of the iron pnictide superconductor KFe_2As_2 (Tc=3.4 K) were examined at temperatures down to 100 mK. Thermodynamic evidence for the presence of line nodes is obtained from the square-root H dependence of C/T in the low-T and low-H regime. Under a magnetic field rotated within the tetragonal ab plane, a fourfold oscillation is observed in Ce and its sign changes at 0.08 Tc. The results indicate that line nodes exist on the superconducting gap where the Fermi velocity is parallel to [100] directions. (2) We measured the temperature dependence of the magnetization M(T) of a S=1/2 one dimensional Heisenberg antiferromagnet CuPzN (interaction parameter J~10 K) near the saturation field Hs~14 T where a quantum phase transition from a Luttinger liquid ground state to a fully polarized state occurs. It is found that M(T) at Hs exhibits a square-root T dependence below ~1 K down to 80 mK, in good agreement with a prediction of the exact solutions.

1. Anomalous Field-Angle Dependence of the Specific Heat of Heavy-Fermion Superconductor UPt_3: S. Kittaka, K. An, T. Sakakibara, Y. Haga, E. Yamamoto, N. Kimura, Y. Onuki and K. Machida, J. Phys. Soc. Jpn. **82** (2013) 024707(1-5).
2. †Coexistence of Ising and XY Spin Systems on a Single Tb Atom in $TbCoGa_5$: N. Sanada, Y. Amou, R. Watanuki, K. Suzuki, I. Yamamoto, H. Mitamura, T. Sakakibara, M. Akatsu, Y. Nemoto and T. Goto, J. Phys. Soc. Jpn. **82** (2013) 044713(1-7).
3. *Evidence of a High-Field Phase in PrV_2Al_{20} in a [100] Magnetic Field: Y. Shimura, Y. Ohta, T. Sakakibara, A. Sakai and S. Nakatsuji, J. Phys. Soc. Jpn. **82** (2013) 043705(1-4).
4. †*High-Field Phase Diagram of $SmRu_4P_{12}$ Determined by Ultrasonic Measurements in Pulsed Magnetic Field up to 55 T: M. Yoshizawa, H. Mitamura, F. Shichinomiya, S. Fukuda, Y. Nakanishi, H. Sugawara, T. Sakakibara and K. Kindo, J. Phys. Soc. Jpn. **82** (2013) 033602(1-5).

* Joint research among groups within ISSP.

5. Verification of Anisotropic *s*-Wave Superconducting Gap Structure in $CeRu_2$ from Low-Temperature Field-Angle-Resolved Specific Heat Measurements: S. Kittaka, T. Sakakibara, M. Hedo, Y. Onuki and K. Machida, J. Phys. Soc. Jpn. **82** (2013) 123706(1-4).

6. †*Long-range order and spin-liquid states of polycrystalline $Tb_{2+x}Ti_{2-x}O_{7+y}$: T. Taniguchi, H. Kadowaki, H. Takatsu, B. Fåk, J. Ollivier, T. Yamazaki, T. J. Sato, H. Yoshizawa, Y. Shimura, T. Sakakibara, T. Hong, K. Goto, L. R. Yaraskavitch and J. B. Kycia, Phys. Rev. B **87** (2013) 060408R(1-5).

7. †*Quasi-one-dimensional S=1/2 Heisenberg antiferromagnetic chain consisting of the organic radical p-Br-V: K. Iwase, H. Yamaguchi, T. Ono, Y. Hosokoshi, T. Shimokawa, Y. Kono, S. Kittaka, T. Sakakibara, A. Matsuo and K. Kindo, Phys. Rev. B **88** (2013) 184431(1-5).

8. †*Various regimes of quantum behavior in an S=1/2 Heisenberg antiferromagnetic chain with fourfold periodicity: H. Yamaguchi, T. Okubo, K. Iwase, T. Ono, Y. Kono, S. Kittaka, T. Sakakibara, A. Matsuo, K. Kindo and Y. Hosokoshi, Phys. Rev. B **88** (2013) 174410(1-5).

9. Determining the Surface-To-Bulk Progression in the Normal-State Electronic Structure of Sr_2RuO_4 by Angle-Resolved Photoemission and Density Functional Theory: C. N. Veenstra, Z. -H. Zhu, B. Ludbrook, M. Capsoni, G. Levy, A. Nicolaou, J. A. Rosen, R. Comin, S. Kittaka, Y. Maeno, I. S. Elfimov and A. Damascelli, Phys. Rev. Lett. **110** (2013) 097004(1-5).

10. †Unconventional Magnetic and Thermodynamic Properties of S=1/2 Spin Ladder with Ferromagnetic Legs: H. Yamaguchi, K. Iwase, T. Ono, T. Shimokawa, H. Nakano, Y. Shimura, N. Kase, S. Kittaka, T. Sakakibara, T. Kawakami and Y. Hosokoshi, Phys. Rev. Lett. **110** (2013) 157205(1-5).

11. 高次多極子がもたらす磁場誘起相：志村 恭通，榊原 俊郎，大貫 惇睦，固体物理 **48** (2013) 721-727.

12. Magnetization steps in Yb_2Pt_2Pb with the Shastry-Sutherland lattice: Y. Shimura, T. Sakakibara, K. Iwakawa, Y. Onuki and K. Sugiyama, J. Kor. Phys. Soc. **63** (2013) 551-554.

13. Singlet-triplet crossover in the two-dimensional dimer spin system $YbAl_3C_3$: S. Kittaka, T. Sugiyama, Y. Shimura, T. Sakakibara, S. Matsuda and A. Ochiai, J. Kor. Phys. Soc. **62** (2013) 2088-2092.

14. †Fine-Tuning of Magnetic Interactions in Organic Spin Ladders: H. Yamaguchi, H. Miyagai, T. Shimokawa, K. Iwase, T. Ono, Y. Kono, N. Kase, K. Araki, S. Kittaka, T. Sakakibara, T. Kawakami, K. Okunishi and Y. Hosokoshi, J. Phys. Soc. Jpn. **83** (2014) 033707(1-4).

15. Novel Electronic States of Heavy Fermion Compound $YbCo_2Zn_{20}$: F. Honda, Y. Taga, Y. Hirose, S. Yoshiuchi, Y. Tomooka, M. Ohya, J. Sakaguchi, T. Takeuchi, R. Settai, Y. Shimura, T. Sakakibara, I. Sheikin, T. Tanaka, Y. Kubo and Y. Onuki, J. Phys. Soc. Jpn. **83** (2014) 044703(1-9).

16. †Possible Evolution of Antiferromagnetism in Zn-Doped Heavy-Fermion Superconductor $CeCoIn_5$: M. Yokoyama, K. Fujimura, S. Ishikawa, M. Kimura, T. Hasegawa, I. Kawasaki, K. Tenya, Y. Kono and T. Sakakibara, J. Phys. Soc. Jpn. **83** (2014) 033706(1-5).

17. Thermodynamic Study of Nodal Structure and Multiband Superconductivity of KFe_2As_2: S. Kittaka, Y. Aoki, N. Kase, T. Sakakibara, T. Saito, H. Fukazawa, Y. Kohori, K. Kihou, C. Ho Lee, A. Iyo, H. Eisaki, K. Deguchi, N. K. Sato, Y. Tsutsumi and K. Machida, J. Phys. Soc. Jpn. **83** (2014) 013704(1-4).

18. †*Field-induced incommensurate phase in the strong-rung spin ladder with ferromagnetic legs: H. Yamaguchi, H. Miyagai, M. Yoshida, M. Takigawa, K. Iwase, T. Ono, N. Kase, K. Araki, S. Kittaka, T. Sakakibara, T. Shimokawa, T. Okubo, K. Okunishi, A. Matsuo and Y. Hosokoshi, Phys. Rev. B **89** (2014) 220402.

19. Measurement of the spin-orbit coupling in superconducting Sr_2RuO_4 using polarized light and spin-resolved photoemission spectroscopy: Evidence for a breakdown in the singlets and triplets pairing mechanisms: C. N. Veenstra, Z. -H. Zhu, M. Raichle, B. M. Ludbrook, A. Nicolaou, B. Slomski, G. Landolt, S. Kittaka, Y. Maeno, J. H. Dil, I. S. Elfimov, M. W. Haverkort and A. Damascelli, Phys. Rev. Lett. **112** (2014) 127002(1-4).

20. Multiband superconductivity with unexpected deficiency of nodal quasiparticles in $CeCu_2Si_2$: S. Kittaka, Y. Aoki, Y. Shimura, T. Sakakibara, S. Seiro, C. Geibel, F. Steglich, H. Ikeda and K. Machida, Phys. Rev. Lett. **112** (2014) 067002(1-5).

21. *Magnetization and Specific Heat of the Caged Compound PrV_2Al_{20}: K. Araki, Y. Shimura, N. Kase, T. Sakakibara, A. Sakai and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

† Joint research with outside partners.

Mori group

We have successfully developed and characterized the functional molecular materials. The major achievements in 2013 are (1) to discover the novel spin liquid state of purely organic single-component crystal κ-H_3(Cat-EDT-TTF)$_2$, (2) to develop the proton-electron coupled molecular conductor with tuning π-electron bandwidth and hydrogen bond, and (3) to clarify the electronic state between 3/4-filled and effective 1/2-filled band structure by optical measurement for pressure-induced superconductor β-(*meso*-DMBEDT-TTF)$_2$$PF_6$.

1. Optical Conductivity Measurement of a Dimer Mott-Insulator to Charge-Order Phase Transition in a Two-Dimensional Quarter-Filled Organic Salt Compound: R. Okazaki, Y. Ikemoto, T. Moriwaki, T. Shikama, K. Takahashi, H. Mori, H. Nakaya, T. Sasaki, Y. Yasui and I. Terasaki, Phys. Rev. Lett. **111** (2013) 217801.
2. †Fabrication of a field effect transistor structure using charge-ordered organic materials α-(BEDT-TTF)$_2$$I_3$ and α′-(BEDT-TTF)$_2$$IBr_2$: M. Kimata, T. Ishihara, A. Ueda, H. Mori and H. Tajima, Synth. Met. **173** (2013) 43-45.
3. Pyridone derivatives carrying radical moieties: Hydrogen-bonded structures, magnetic properties, and metal coordination: M. Ueda, T. Mochida and H. Mori, Polyhedron **52** (2013) 755-760.
4. Crystal Architectures and Magnetic Properties of Alkylferrocenium Salts with F_nTCNQ(n = 0, 2, 4): Effect of Substituents on the Self-Assembled Structures: T. Mochida, T. Akasaka, Y. Funasako, Y. Nishio and H. Mori, Crystal Growth & Design **13** (2013) 4460.
5. Hydrogen bond-promoted metallic state in a purely organic single-component conductor under pressure: T. Isono, H. Kamo, A. Ueda, K. Takahashi, A. Nakao, R. Kumai, H. Nakao, K. Kobayashi, Y. Murakami and H. Mori, Nat. Commun. **4** (2013) 1344-1349.
6. Gapless Quantum Spin Liquid in an Organic Spin-1/2 Triangular-Lattice κ-H_3(Cat-EDT-TTF)$_2$: T. Isono, H. Kamo, A. Ueda, K. Takahashi, M. Kimata, H. Tajima, S. Tsuchiya, T. Terashima, S. Uji and H. Mori, Phys. Rev. Lett. **112** (2014) 177201.
7. Biferrocenium salts with magnetite-like mixed-valence iron: coexistence of Fe^{3+} and $Fe^{2.5+}$ in the crystal: T. Mochida, E. Nagabuchi, M. Takahashi and H. Mori, Chem. Commun. **50** (2014) 2481.
8. Protonation of Pyridyl-Substituted TTF Derivatives: Substituent Effects in Solution and in the Proton-Electron Correlated Charge-Transfer Complexes: S. C. Lee, A. Ueda, A. Nakao, R. Kumai, H. Nakao, Y. Murakami and H. Mori, Chem. Eur. J. **20** (2014) 1909.
9. Charge-Transfer Salts of Biferrocene Derivatives with F_2- and F_4-Tetracyanoquinodimethane: Correlation Between Donor–Acceptor Ratios and Cation Valence States: T. Mochida, Y. Funasako, E. Nagabuchi and H. Mori, Crystal Growth & Design **14** (2014) 1459.
10. Synergistic Spin Transition between Spin Crossover and Spin-Peierls-like Singlet Formation in the Halogen-Bonded Molecular Hybrid System: [Fe(Iqsal)$_2$][Ni(dmit)$_2$]·CH_3CN·H_2O: K. Fukuroi, K. Takahashi, T. Mochida, T. Sakurai, H. Ohta, T. Yamamoto, Y. Einaga and H. Mori, Angew. Chem. Int. Ed. **53** (2014) 1983.
11. 単成分純有機金属材料で金属伝導は可能か？：森 初果 , 上田 顕 , 化学 **68** (2013) 64-65.
12. 磁性と伝導性が相関した多重機能性分子性物質の開発：森 初果 , 高橋 一志 , まぐね **8** (2013) 148-154.
13. はたらくこと　生きること理工系女性の想い：森 初果 , 日刊工業新聞 (2013).
14. 化学の力を生かした新しい分子性機能材料の開発：森 初果 , 化学 **69, No1** (2014) 20-21.
15. 金属状態を示す純有機単成分導体：森 初果 , 工業材料 **62　No1** (2014) 26-27.

Nakatsuji group

Our group explores novel quantum phases and phase transitions in rare-earth and transition metal based compounds. The followings are some relevant results obtained in 2013. (1) We have found that the metallic spin ice compound $Pr_2Ir_2O_7$ exhibits quantum criticality in a nontrivial semimetallic state. (2) The Fe doping at the Al site in α-$YbAlB_4$ induces an antiferromagnetic ordering whose ordering temperature goes up to 10 K, which is the highest among the Yb based heavy fermion materials. The large enhancement of the magnetic ordering indicates that the mixed valence plays an important role. (3) Finally, our success in synthesizing high quality single crystals of $PrTr_2Al_{20}$ allows us to reveal that the superconductivity in $PrTi_2Al_{20}$ and the antiferro-quadrupolar transition in PrV_2Al_{20} can be easily suppressed by disorder. This highlights the importance of high quality crystals for the study of strong hybridization effects in quadrupolar Kondo systems.

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* Joint research among groups within ISSP.

1. Conduction electron spin resonance in AlB_2: L. M. Holanda, L. Mendonça-Ferreira, R. A. Ribeiro, J. M. Osorio-Guillén, G. M. Dalpian, K. Kuga, S. Nakatsuji, Z. Fisk, R. R. Urbano, P. G. Pagliuso and C. Rettori, J. Phys.: Condens. Matter **25** (2013) 216001.

2. [*]Evidence of a High-Field Phase in PrV_2Al_{20} in a [100] Magnetic Field: Y. Shimura, Y. Ohta, T. Sakakibara, A. Sakai and S. Nakatsuji, J. Phys. Soc. Jpn. **82** (2013) 043705(1-4).

3. Determination of long-range all-in-all-out ordering of Ir^{4+} moments in a pyrochlore iridate $Eu_2Ir_2O_7$ by resonant x-ray diffraction: H. Sagayama, D. Uematsu, T. Arima, K. Sugimoto, J. J. Ishikawa, E. O'Farrell and S. Nakatsuji, Phys. Rev. B **87** (2013) 100403(4 pages).

4. Magnetic excitations and c-f hybridization effect in $PrTi_2Al_{20}$and PrV_2Al_{20}: Y. Tokunaga, H. Sakai, S. Kambe, A. Sakai, S. Nakatsuji and H. Harima, Phys. Rev. B **88** (2013) 085124.

5. Dynamical spin–orbital correlation in the frustrated magnet $Ba_3CuSb_2O_9$: Y. Ishiguro, K. Kimura, S. Nakatsuji, S. Tsutsui, A. Q. R. Baron, T. Kimura and Y. Wakabayashi, Nat. Commun. **4** (2013) 2022(1-6).

6. Quantum fluctuations in spin-ice-like $Pr_2Zr_2O_7$: K. Kimura, S. Nakatsuji, J.-J. Wen, C. Broholm, M. B. Stone, E. Nishibori and H. Sawa, Nat. Commun. **4** (2013) 1934(1-6).

7. [*]Chemical effects of high-resolution Yb $L\gamma_4$ emission spectra: a possible probe for chemical analysis: H. Hayashi, N. Kanai, N. Kawamura, Y. H. Matsuda, K. Kuga, S. Nakatsuji, T. Yamashita and S. Ohara, X-Ray Spectrom. **42** (2013) 450-455.

8. Low temperature transport properties of the quadrupolar Kondo lattice system $PrTi_2Al_{20}$: A. Sakai and S. Nakatsuji, J. Kor. Phys. Soc. **63** (2013) 398-400.

9. Magnetic order induced by Fe doping in the intermediate valence system β-$YbAlB_4$: K. Kuga and S. Nakatsuji, J. Kor. Phys. Soc. **63** (2013) 549-550.

10. Mössbauer spectroscopy of Fe-doped valence-fluctuating α-$YbAlB_4$: Y. Sakaguchi, S. Ikeda, H. Kobayashi, K. Kuga, K. Sone and S. Nakatsuji, J. Kor. Phys. Soc. **62** (2013) 2146-2149.

11. Single-crystal study on the low-temperature magnetism of the pyrochlore magnet $Pr_2Zr_2O_7$: K. Kimura, S. Nakatsuji and A. A. Nugroho, J. Kor. Phys. Soc. **63** (2013) 719-721.

12. [*]Synchrotron X-ray spectroscopy study on the valence state in α- and β-$YbAlB_4$ at low temperatures and high magnetic fields: Y. H. Matsuda, T. Nakamura, K. Kuga, S. Nakatsuji, S. Michimura, T. Inami, N. Kawamura and M. Mizumaki, J. Kor. Phys. Soc. **62** (2013) 1778-1781.

13. Quantum criticality in a metallic spin liquid: Y. Tokiwa, J. J. Ishikawa, S. Nakatsuji and P. Gegenwart, Nature Mater. **13** (2014) 356.

14. X-ray Photoemission and X-ray Absorption Spectroscopy of Hexagonal $Ba_3CuSb_2O_9$: T. Sugimoto, T. Mizokawa, H. Wadati, K. Takubo, A. Damascelli, T. Z. Regier, G. A. Sawatzky, N. Katayama, H. Sawa, K. Kimura and S. Nakatsuji, J. Kor. Phys. Soc. **63** (2014) 549-550.

15. [*]Heavy fermion superconductivity under pressure in the quadrupole system $PrTi_2Al_{20}$: K. Matsubayashi, T. Tanaka, J. Suzuki, A. Sakai, S. Nakatsuji, K. Kitagawa, Y. Kubo and Y. Uwatoko, J. Phys. Soc. Jpn. (2014), in print.

16. Magnetic and Thermal Properties of the Single Crystalline $Pr_2Zr_2O_7$ in a [111] field: K. Kimura and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

17. [*]Magnetization and Specific Heat of the Caged Compound PrV_2Al_{20}: K. Araki, Y. Shimura, N. Kase, T. Sakakibara, A. Sakai and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

18. [*]Magnetization of Yb-based mixed-valent compounds at megagauss fields: T. Terashima, Y. H. Matsuda, K. Kuga, Y. Matsumoto and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

19. Sample Dependence of the Quadrupolar Transition in the Nonmagnetic cubic Γ_3 Compound PrV_2Al_{20}: M. Tsujimoto, A. Sakai and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

20. Structural and Magnetic Properties of α-$Yb(Al_{1-x}Fe_x)B_4$ under Hydtostatic Pressure: Y. Sakaguchi, S. Ikeda, K. Kuga, S. Nakatsuji, N. Hirao, Y. Ohishi and H. Kobayashi, J. Phys. Soc. Jpn. (2014), in print.

21. Superconducting properties of the ferroquadrupolar cubic Γ_3 compound $PrTi_2Al_{20}$: A. Sakai, K. Kuga and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

[†] Joint research with outside partners.

22. Suppression of the Heavy Fermion State in Magnetic Fields in the Mixed Valent α-$YbAlB_4$: Y. Matsumoto, K. Kentaro and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

23. Two magnetic phases in α-$YbAl_{1-x}Fe_xB_4$: K. Kuga, S. Suzuki and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

24. 銅酸化物における乱れに強い量子液体状態：中辻 知 , 澤 博 ,「超伝導現象と高温超伝導体」, 新日本編集企画 , (NTS 出版社 , 2013), 475-481.

Ohgushi group

Our group is focused on an exploratory synthesis and characterization of oxides, chalcogenides, and intermetallics. The major achievements in the fiscal year 2013 are (1) finding of new superconductivity in anti-post-perovskite compounds, and (2) elucidation of orbital states of iridium oxides by means of resonant x-ray diffraction.

1. *Observation of Phonon-Assisted Magnon Absorption in Spin–Orbit Coupling Induced Mott Insulator Sr_2IrO_4: Y. Hirata, H. Tajima and K. Ohgushi, J. Phys. Soc. Jpn. **82** (2013) 035002(1-2).

2. Complex orbital state stabilized by strong spin-orbit coupling in a metallic iridium oxide IrO_2: Y. Hirata, K. Ohgushi, J.-I. Yamaura, H. Ohsumi, S. Takeshita, M. Takata and T. Arima, Phys. Rev. B **87** (2013) 161111(1-5).

3. Magnetoelasticity in ACr_2O_4 spinel oxides (A = Mn, Fe, Co, Ni, and Cu): V. Kocsis, S. Bordács, D. Varjas, K. Penc, A. Abouelsayed, C. A. Kuntscher, K. Ohgushi, Y. Tokura and I. Kézsmárki, Phys. Rev. B **87** (2013) 064416(1-9).

4. *Mechanism of Enhanced Optical Second-Harmonic Generation in the Conducting Pyrochlore-Type $Pb_2Ir_2O_{7-x}$ Oxide Compound: Y. Hirata, M. Nakajima, Y. Nomura, H. Tajima, Y. Matsushita, K. Asoh, Y. Kiuchi, A. G. Eguiluz, R. Arita, T. Suemoto and K. Ohgushi, Phys. Rev. Lett. **110** (2013) 187402(1-5).

5. Resonant X-ray Diffraction Study of the Strongly Spin-Orbit-Coupled Mott Insulator $CaIrO_3$: K. Ohgushi, J.-I. Yamaura, H. Ohsumi, K. Sugimoto, S. Takeshita, A. Tokuda, H. Takagi, M. Takata and T.-H. Arima, Phys. Rev. Lett. **110** (2013) 217212(1-5).

6. *Hydrostatic pressure (8GPa) dependence of electrical resistivity of $BaCo_2As_2$ single crystal: C. Ganguli, K. Matsubayashi, K. Ohgushi, Y. Uwatoko, M. Kanagaraj and S. Arumugam, Mat. Res. Bull. **48** (2013) 4329-4331.

7. †Suppression of Intersite Charge Transfer in Charge-Disproportionated Perovskite $YCu_3Fe_4O_{12}$: H. Etani, I. Yamada, K. Ohgushi, N. Hayashi, Y. Kusano, M. Mizumaki, J. Kim, N. Tsuji, R. Takahashi, N. Nishiyama, T. Inoue, T. Irifune and M. Takano, J. Am. Chem. Soc. **135** (2013) 6100-6106.

8. *5d 遷移金属パイロクロア酸化物における低温磁気構造の研究：山浦 淳一 , 大串 研也 , 広井 善二 , 日本結晶学会誌 **55** (2013) 116-120.

9. †Control of Bond-Strain-Induced Electronic Phase Transitions in Iron Perovskites: I. Yamada, H. Etani, K. Tsuchida, S. Marukawa, N. Hayashi, T. Kawakami, M. Mizumaki, K. Ohgushi, Y. Kusano, J. Kim, N. Tsuji, R. Takahashi, N. Nishiyama, T. Inoue, T. Irifune and M. Takano, Inorg. Chem. **52** (2013) 13751-13761.

10. †*B*-Site Deficiencies in *A*-site-Ordered Perovskite $LaCu_3Pt_{3.75}O_{12}$: M. Ochi, I. Yamada, K. Ohgushi, Y. Kusano, M. Mizumaki, R. Takahashi, S. Yagi, N. Nishiyama, T. Inoue and T. Irifune, Inorg. Chem. **52** (2013) 3985-3989.

11. †Pd^{2+}-Incorporated Perovskite $CaPd_3B_4O_{12}$(B = Ti, V): K. Shiro, I. Yamada, N. Ikeda, K. Ohgushi, M. Mizumaki, R. Takahashi, N. Nishiyama, T. Inoue and T. Irifune, Inorg. Chem. **52** (2013) 1604-1609.

12. Superconductivity in anti-post-perovskite vanadium compounds: B. Wang and K. Ohgushi, Sci. Rep. **3** (2013) 3381.

13. †NMR study of successive magnetic transitions in the A-site ordered perovskite $LaMn_3Cr_4O_{12}$: Y. Kawasaki, S. Takase, Y. Kishimoto, T. Ohno, I. Yamada, K. Shiro, R. Takahashi, K. Ohgushi, N. Nishiyama, T. Inoue and T. Irifune, J. Kor. Phys. Soc. **63** (2013) 640-643.

14. *High-pressure effects in anti-post-perovskite superconductors V_3PnN_x (Pn = P, As): B. S. Wang, J. -G. Cheng, K. Matsubayashi, Y. Uwatoko and K. Ohgushi, Phys. Rev. B **89** (2014) 144510 (1-4).

15. Magnetoelectric responses from the respective magnetic R and Fe subsystems in the noncentrosymmetric antiferromagnets $RFe_3(BO_3)_4$ (R = Eu, Gd, and Tb): T. Kurumaji, K. Ohgushi and Y. Tokura, Phys. Rev. B **89** (2014) 195126 (1-13).

* Joint research among groups within ISSP.

16. *Pseudogap formation above the superconducting dome in iron pnictides: T. Shimojima, T. Sonobe, W. Malaeb, K. Shinada, A. Chainani, S. Shin, T. Yoshida, S. Ideta, A. Fujimori, H. Kumigashira, K. Ono, Y. Nakashima, H. Anzai, M. Arita, A. Ino, H. Namatame, M. Taniguchi, M. Nakajima, S. Uchida, Y. Tomioka, T. Ito, K. Kihou, C. H. Lee, A. Iyo, H. Eisaki, K. Ohgushi, S. Kasahara, T. Terashima, H. Ikeda, T. Shibauchi, Y. Matsuda and K. Ishizaka, Phys. Rev. B **89** (2014) 045101(1-10).

17. $CaIrO_3$: a Spin-Orbit Mott Insulator Beyond the j_{eff} = 1/2 Ground State: M. Moretti Sala, K. Ohgushi, A. Al-Zein, Y. Hirata, G. Monaco and M. Krisch, Phys. Rev. Lett. **112** (2014) 176402.

18. ポストペロブスカイト型化合物 $CaIrO_3$ の磁気構造：大串 研也，大隅 寛幸，山浦 淳一，有馬 孝尚，日本結晶学会誌 **56** (2014) 36.

Division of Condensed Matter Theory

K. Ueda group

When a simple lattice is depleted in a periodic manner, electronic states of a tight binding model on such a depleted lattice sometimes shows a peculiar feature like a flat band or a Dirac cone. A typical example is the triangular lattice: the honeycomb lattice is obtained by the one third depletion and the kagome lattice by the one quarter depletion. In 2013, we concentrated on the quantum phase transitions of the Hubbard model on the one fifth depleted square lattice. This structure exists in nature in CaV4O9 and in some iron pnictide compound. At quarter filling the Dirac cone at the gamma point coincides with the Fermi energy and furthermore the Dirac cone touches with an almost flat band forming an SU(3) multiplet. We have shown that quantum phase transitions around the symmetric point is controlled by the SU(3) Dirac electrons. At half filling the effective theory in the strong coupling limit is a Heisenberg model which shows quantum phase transitions from the dimer singlet to the antiferromagnetic phase and further onto the plaquette singlet phase. Quantum phase transitions of the Hubbard model on this lattice have been investigated by using the cluster dynamical mean field theory.

1. SU(3) Dirac Electrons in the 1/5-Depleted Square-Lattice Hubbard Model at 1/4-Filling: Y. Yamashita, M. Tomura, Y. Yanagi and K. Ueda, Phys. Rev. B **88** (2013) 195104(1-7).

Takada group

Employing several techniques including the Green's-function approach, the density-matrix renormalization group, quantum Monte Carlo simulations, band-structure calculations, and several types of variational approaches, we are studying various aspects of quantum many-body problems in condensed matter physics, based mainly on the first-principles Hamiltonian. This year we have studied the following issues: (1) In order to better reproduce the electron-density profile obtained by the diffusion Monte Carlo method for the system of a single atom embedded in the electron gas with arbitrary densities, we have improved on the GGA-PBE version of the exchange-correlation energy functional in the density functional theory. In making this improvement, we have paid special attention to fulfilling the cusp theorem at the atom site. The improved functional will be applied to a wide range of topics in the future, including the phase diagram of the solid hydrogen under high pressures. (2) A further analysis is made for an electron-like elementally excitation (pseudoelectron) in the Luttinger liquid in competition with the spinon and holon excitations by using the powerful self-consistent numerical GWΓ scheme. (3) Mechanisms of superconductivity are considered in the low-density system in the framework of the ***kp*** perturbation theory with application to the n-type doped $SrTiO_3$. We have considered the effects of various issues such as the ferroelectric soft-phonon exchange, the plasmon contribution, the band multiplicity and the spin-orbit interaction.

1. 第1原理からの超伝導理論：高田 康民，物性研究 電子版 **Vol.3, No.1** (2013) 031203(1-29).

2. Structural evolution of the one-dimensional spectral function from the low- to the high-energy limit: H. Maebashi and Y. Takada, Phys. Rev. B **89** (2014) 201109(R) (1-5).

3. Theory for Reliable First-Principles Prediction of the Superconducting Transition Temperature: Y. Takada, in: *Carbon-based New Superconductors: Toward high-Tc superconductivity (ISBN 978-981-4303-30-9 (Hardcover), 978-981-4303-31-6 (eBook))*, Ch 8, edited by J. Haruyama, (Pan Stanford Publishing Pte. Ltd., 2014), 38page.

Oshikawa group

We studied a wide range of fundamental problems in condensed matter theory and statistical mechanics. In particular, we investigated the effects of quantum particle statistics on the ground-state energy. In the case of free particles, a ground state of bosons is given by a Bose-Einstein Condensation of all the particles into the lowest-energy single-particle state. In contrast, the ground

† Joint research with outside partners.

state of fermions is given by putting the particles to lowest-energy single-particle state, but with the restriction that no more than one particle can occupy an identical state (Pauli exclusion principle). Thus the ground-state energy for the identical Hamiltonian would be higher in the case of fermions, compared to the case of bosons. However, the comparison becomes not trivial when the particles are interacting. In fact, we established several examples in which the hard-core bosons have a higher ground-state energy than the corresponding fermions. We have also provided a novel understanding how the particle statistics affects the ground-state energy: Fermi statistics introduces a sort of frustration among hoppings of many particles. When there is no other frustration among hoppings, we proved that the bosons have a lower ground-state energy than the corresponding fermions, even in the presence of interactions. On the other hand, when frustration is introduced through phases of hopping amplitudes, the effects may partially cancel with each other, resulting in a reversal of the ground-state energy.

1. †Dimensional crossover in layered f-electron superlattices: Y. Tada, R. Peters and M. Oshikawa, Phys. Rev. B **88** (2013) 235121 (1-7).

2. †Electron spin resonance shifts in S=1 antiferromagnetic chains: S. C. Furuya, Y. Maeda and M. Oshikawa, Phys. Rev. B **87** (2013) 125122 (1-10).

3. †Entanglement spectra between coupled Tomonaga-Luttinger liquids: Applications to ladder systems and topological phases: R. Lundgren, Y. Fuji, S. Furukawa and M. Oshikawa, Phys. Rev. B **88** (2013) 245137 (1-14).

4. †Hole statistics and superfluid phases in quantum dimer models: C. A. Lamas, A. Ralko, M. Oshikawa, D. Poilblanc and P. Pujol, Phys. Rev. B **87** (2013) 104512(1-20).

5. †Response to a twist in systems with Z_p symmetry: The two-dimensional p-state clock model: Y. Kumano, K. Hukushima, Y. Tomita and M. Oshikawa, Phys. Rev. B **88** (2013) 104427 (1-6).

6. †Ground-State Energies of Spinless Free Fermions and Hard-Core Bosons: W. Nie, H. Katsura and M. Oshikawa, Phys. Rev. Lett. **111** (2013) 100402 (1-5).

7. †Quantum criticality in an asymmetric three-leg spin tube: A strong rung-coupling perspective: Y. Fuji, S. Nishimoto, H. Nakada and M. Oshikawa, Phys. Rev. B **89** (2014) 054425 (1-13).

8. †Valence bond distribution and correlation in bipartite Heisenberg antiferromagnets: D. Schwandt, F. Alet and M. Oshikawa, Phys. Rev. B **89** (2014) 104416 (1-14).

Tsunetsugu group

We have investigated novel phases of non-Kramers doublets realized in the heavy fermion compound $PrIr_2Zn_{20}$ and related materials. Non-Kramers doublet is a ground state of f^2 electron configuration protected by cubic symmetry of the crystalline field. Based on a microscopic model and an effective field theory, we have used symmetry arguments and mean-field approach to study possible symmetry breaking at low temperatures with and without magnetic field. We have found various antiferro quadrupole ordered phases depending on the magnetic field direction. The most important ingredient is the presence of a unique Z_3 anisotropy in the order parameter space, and in particular, the zero-field order corresponds to the spontaneous breaking of $Z_3 \times Z_2$ symmetry. This also results in unusual divergence of quadrupole susceptibility in several channels near the critical point. This may be related to observed singularity in ultrasound measurements. We have also numerically studied doublon dynamics near the Mott metal-insulator transition. It has been long believed that the Mott transition is a binding-unbinding transition of doublons and holons, but this point has been directly examined only by equal-time correlations. We have performed large-scale computations of cluster dynamical mean-field theory for the half-filled Hubbard model on the triangular lattice, and calculated dynamical correlations of doublons and holons on the same site and also between nearest-neighbor sites. The results show drastic changes in their dynamics between the metallic and insulating phases. In particular, the doublon-holon pair correlation shows fluctuations up to a very long time in the metallic phase, while the correlation decays very quickly in the insulating phase. This supports the binding-unbinding transition picture of the Mott transition. (Reference: Toshihiro Sato and Hirokazu Tsunetsugu, arXiv:1404.6598) Quantum impurities coupled to Tomonaga-Luttinger liquids are interesting physical systems including an impurity in quantum wire, a spin coupled to a two-dimensional topological insulator etc. We have developed a new method of quantum Monte Carlo simulation with continuous time formulation. This is base on the duality between electrons and bosons, and this results in the advantage of negative sign free nature. The new method is applied to various problems and scaling properties of correlation functions are examined. (Reference: K. Hattori and A. Rosch, arXiv: 1405.3300)

1. Continuous-Time Quantum Monte Carlo Approach for Impurity Anderson Models with Phonon-Assisted Hybridizations: K. Hattori, J. Phys. Soc. Jpn. **82** (2013) 064709 (5 pages).

2. Exotic disordered phases in the quantum J1-J2 model on the honeycomb lattice: H. Zhang and C. A. Lamas, Phys. Rev. B **87** (2013) 024415 (10 pages).

3. p-wave superconductivity near a transverse saturation field: K. Hattori and H. Tsunetsugu, Phys. Rev. B **87** (2013) 064501 (5 pages).

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* Joint research among groups within ISSP.

4. Antiferro Quadrupole Orders in Non-Kramers Doublet Systems: K. Hattori and H. Tsunetsugu, J. Phys. Soc. Jpn. **83** (2014) 034709 (19 pages).

Kohmoto group

Energy versus magnetic field (Hofstadter butterfly diagram) in twisted bilayer graphene is studied theoretically. If we take the usual Landau gauge, we cannot take a finite periodicity even when the magnetic flux through a supercell is a rational number. We show that the periodic Landau gauge, which has the periodicity in one direction, makes it possible to obtain the Hofstadter butterfly diagram. Since a supercell can be large, magnetic flux through a supercell normalized by the flux quantum can be a fractional number with a small denominator, even when a magnetic field is not extremely strong. As a result, quantized Hall conductance can be a solution of the Diophantine equation which cannot be obtained by the approximation of the linearized energy dispersion near the Dirac points.

1. †Periodic Landau gauge and quantum Hall effect in twisted bilayer graphene: Y. Hasegawa and M. Kohmoto, Phys. Rev. B **88** (2013) 125426(1-8).

2. †The Spectral Shift Function and the Friedel Sum Rule: M. Kohmoto, T. Koma and S. Nakamura, Ann. Henri Poincaré **14** (2013) 1413-1424.

Sugino group

We have advanced the first-principles molecular dynamics approach to the electrochemical interfaces. This was done by improving the effective screening medium (ESM) method. With the method, new results was obtained regarding the planar and particle catalysts and the mechanism of the reactions. We have continued to develop a many-body Green's function approach to the spectroscopy and began to obtain promising results. Progress has been made on the tensor network approach to obtain accurate density matrix of molecules.

1. Improved modeling of electrified interfaces using the effective screening medium method: I. Hamada, O. Sugino, N. Bonnet and M. Otani, Phys. Rev. B **88** (2013) 155427.

2. Nonadiabatic couplings from time-dependent density functional theory: Formulation by the Kohn-Sham derivative matrix within density functional perturbation theory: C. Hu, T. Tsukagoshi, O. Sugino and K. Watanabe, Phys. Rev. B **87** (2013) 035421(1-7).

3. Reply to “Comment on ‘Nonadiabatic couplings from the Kohn-Sham derivative matrix: Formulation by time-dependent density-functional theory and evaluation in the pseudopotential framework’”: C. Hu, O. Sugino, H. Hirai and Y. Tateyama, Phys. Rev. A **88** (2013) 056502.

4. First-Principles Investigation on Structural and Optical Properties of $M^+@C_{60}$ (Where M = H, Li, Na, and K): Y. Noguchi, O. Sugino, H. Okada and Y. Matsuo, J. Phys. Chem. C **117** (2013) 15362.

5. 白金電極上における水素発生反応の第一原理的理解に向けて : I. Hamada and O. Sugino, J. Surf. Sci. Soc. Jpn. **34** (2013) 638.

6. Microscopic understanding of the electrochemical interfaces: O. Sugino, AIP Conf. Proc. **1568** (2013) 43.

7. Electronic structures of oxygen-deficient Ta_2O_5: Y. Yang, H.-H. Nahm, O. Sugino and T. Ohno, AIP Advances **3** (2013) 042101(1-8).

8. Effect of thermal motion on catalytic activity of nanoparticles in polar solvent: N. Bonnet, O. Sugino and M. Otani, J. Chem. Phys. **140** (2014) 044703.

9. Performance of Tamm-Dancoff approximation on nonadiabatic couplings by time-dependent density functional theory: C. Hu, O. Sugino and K. Watanabe, J. Chem. Phys. **140** (2014) 054106.

10. First-principles thermodynamic description of hydrogen electroadsorption on the Pt(111) surface: T. T. T. Hanh, Y. Takimoto and O. Sugino, Surf. Sci. **625** (2014) 104.

Kato group

The main research subject in our laboratory is theory of nonequilibrium properties in nanoscale devices. We have performed (1) evaluation of coherence in single-photon and single-electron generation quantum, (2) exact calculation of transport properties in the Anderson impurity at high bias voltages, and (3) Kondo-like phenomena in heat transport through a local two-state system.

† Joint research with outside partners.

1. Properties of a Single Photon Generated by a Solid-State Emitter: Effects of Pure Dephasing: E. Iyoda, T. Kato, T. Aoki, K. Edamatsu and K. Koshino, J. Phys. Soc. Jpn. **82** (2013) 014301(1-10).

2. Relaxor Behavior and Morphotropic Phase Boundary in a Simple Model: Y. Tomita and T. Kato, J. Phys. Soc. Jpn. **82** (2013) 063002(1-5).

3. Exact interacting Green's function for the Anderson impurity at high bias voltages: A. Oguri and R. Sakano, Phys. Rev. B **88** (2013) 155424(1-12).

4. [*]Experimental Verification of Comparability between Spin-Orbit and Spin-Diffusion Lengths: Y. Niimi, D. Wei, H. Idzuchi, T. Wakamura, T. Kato and Y. Otani, Phys. Rev. Lett. **110** (2013) 016805.

5. Kondo Signature in Heat Transfer via a Local Two-State System: K. Saito and T. Kato, Phys. Rev. Lett. **111** (2013) 214301(1-5).

6. 1/(N − 1) expansion approach to full-counting statistics for the SU(N) Anderson model: A. Oguri and R. Sakano, J. Kor. Phys. Soc. **63** (2013) 423-427.

7. Dephasing in single-electron generation due to environmental noise probed by Hong-Ou-Mandel interferometry: E. Iyoda, T. Kato, K. Koshino and T. Martin, Phys. Rev. B **89** (2014) 205318(1-8).

8. メゾスコピック系の物理―基礎から最近の話題まで―（第 58 回物性若手夏の学校：講義）：加藤 岳生，物性研究・電子版 **3** (2014) 031201(1-26).

Division of Nanoscale Science

Iye group

Thermoelectric effect and high frequency conduction in GaAs/AlGaAs 2DEG subjected to periodic potential modulation (lateral superlattice) has been investigated. Commensurability oscillation in thermoelectric power is observed in one-dimensional lateral superlattice sample. AC conductivity in the quantum Hall plateau region of a hexagonal lateral superlattice sample exhibits a few characteristic resonance peaks.

1. [*]Control of magnetic anisotropy in (Ga,Mn)As with etching depth of specimen boundaries: Y. Hashimoto, Y. Iye and S. Katsumoto, J. Cryst. Growth **378** (2013) 381.

2. [*]Suppression of Andreev current due to transverse current flow in an InAs two-dimensional electrons: Y. Takahashi, Y. Hashimoto, Y. Iye and S. Katsumoto, J. Cryst. Growth **378** (2013) 400.

3. [*]Spin Hall reduction of Josephson effect in InAs two-dimensional electrons: T. Nakamura, Y. Takahashi, Y. Hashimoto, D. H. Yun, S. W. Kim, Y. Iye and S. Katsumoto, Phys. Status Solidi C **10** (2013) 1473.

4. Commensurability oscillations in the rf conductivity of unidirectional lateral superlattices: measurement of anisotropic conductivity by coplanar waveguide: A. Endo, T. Kajioka and Y. Iye, J. Phys. Soc. Jpn **82** (2013) 054710(1-7).

5. Diffusion Thermopower of Quantum Hall States Measured in Corbino Geometry: S. Kobayakawa, A. Endo and Y. Iye, J. Phys. Soc. Jpn **82** (2013) 053702(1-4).

6. [*]Mechanical modification of magnetic anisotropy in (Ga,Mn)As: Y. Hashimoto, Y. Iye and S. Katsumoto, in: *AIP Conference Proceedings "International Conference on Physics of Semiconductors"*, edited by T. Ihn (AIP, 2013), 347.

Katsumoto group

The two-electron tunneling process to a side-coupled quantum dot has been applied to detect spin polarization in the target device. The method is most powerful among so far developed and the device voltage dependence can be measured. We have revealed that the polarization mechanism at so called 0.5 plateau is the Stern-Gelach type spin-filter while that at 1.0 plateau is the spin rotation predicted a decade ago.

1. Robustness of spin filtering against current leakage in a Rashba-Dresselhaus-Aharonov-Bohm interferometer: S. Matityahu, A. Aharony, O. Entin-Wohlman and S. Katsumoto, Phys. Rev. B **87** (2013) 205438(1-8).

2. [†*]Adiabatic measurements of magneto-caloric effects in pulsed high magnetic fields up to 55 T: T. Kihara, Y. Kohama, Y. Hashimoto, S. Katsumoto and M. Tokunaga, Rev. Sci. Instrum. **84** (2013) 074901(1-7).

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* Joint research among groups within ISSP.

3. *Control of magnetic anisotropy in (Ga,Mn)As with etching depth of specimen boundaries: Y. Hashimoto, Y. Iye and S. Katsumoto, J. Cryst. Growth **378** (2013) 381.

4. *Suppression of Andreev current due to transverse current flow in an InAs two-dimensional electrons: Y. Takahashi, Y. Hashimoto, Y. Iye and S. Katsumoto, J. Cryst. Growth **378** (2013) 400.

5. *Spin Hall reduction of Josephson effect in InAs two-dimensional electrons: T. Nakamura, Y. Takahashi, Y. Hashimoto, D. H. Yun, S. W. Kim, Y. Iye and S. Katsumoto, Phys. Status Solidi C **10** (2013) 1473.

6. *Heat-pulse measurements of specific heat in 36 ms pulsed magnetic fields: Y. Kohama, Y. Hashimoto, S. Katsumoto, M. Tokunaga and K. Kindo, Meas. Sci. Technol. **24** (2013) 115005(1-9).

7. Effect of transverse current on Andreev bound state: Y. Takahashi, Y. Hashimoto, D. H. Yun, S. W. Kim, T. Nakamura, Y. Iye and S. Katsumoto, in: *AIP Conference Proceedings, "International Conference on Physics of Semiconductors"*, edited by T. Ihn (AIP, 2013), 345.

8. *Mechanical modification of magnetic anisotropy in (Ga,Mn)As: Y. Hashimoto, Y. Iye and S. Katsumoto, in: *AIP Conference Proceedings "International Conference on Physics of Semiconductors"*, edited by T. Ihn (AIP, 2013), 347.

9. 量子の匠：勝本 信吾 , (丸善 , 東京 , 2014).

Otani group

We have studied on three topics including spin Hall effect, spin diffusion length, and magnonic crystals. Firstly we have applied our non-local spin injection technique to 5d iridium oxide, and succeeded in detecting a very large inverse spin Hall resistivity at room temperature which guarantees this material as a good spin current detector. Secondly we experimentally confirmed that weak antilocalization measurements can be employed as a complementary method for determining the spin diffusion lengths of noble metals. Thirdly in collaboration with Indian group lead by Prof. Barman in Bose Center Kolkata, we have performed all-optical time-resolved magneto-optical Kerr microscope measurements and found that the anisotropic propagation of spin waves are tunable by arranging different symmetries in the form of artificial ferromagnetic nanodot lattices. The observations are important for further development in magnonic crystal based devices.

1. *Experimental Verification of Comparability between Spin-Orbit and Spin-Diffusion Lengths: Y. Niimi, D. Wei, H. Idzuchi, T. Wakamura, T. Kato and Y. Otani, Phys. Rev. Lett. **110** (2013) 016805.

2. Configurational anisotropic spin waves in cross-shaped $Ni_{80}Fe_{20}$ nanoelements: B. K. Mahato, B. Rana, R. Mandal, D. Kumar, S. Barman, Y. Fukuma, Y. Otani and A. Barman, Appl. Phys. Lett. **102** (2013) 192402.

3. Impact of interface properties on spin accumulation in dual-injection lateral spin valves: H. Idzuchi, S. Karube, Y. Fukuma, T. Aoki and Y. Otani, Appl. Phys. Lett. **103** (2013) 162403.

4. Spin injection properties in trilayer graphene lateral spin valves: Y. P. Liu, H. Idzuchi, Y. Fukuma, O. Rousseau, Y. Otani and W. S. Lew, Appl. Phys. Lett. **102** (2013) 033105.

5. Tunable Magnonic Spectra in Two-Dimensional Magnonic Crystals with Variable Lattice Symmetry: S. Saha, R. Mandal, S. Barman, D. Kumar, B. Rana, Y. Fukuma, S. Sugimoto, Y. Otani and A. Barman, Adv. Funct. Mater. **23** (2013) 2378.

6. 5d iridium oxide as a material for spin-current detection: K. Fujiwara, Y. Fukuma, J. Matsuno, H. Idzuchi, Y. Niimi, Y. Otani and H. Takagi, Nat. Commun. **4** (2013) 3893.

7. Propagation of nonlinearly generated harmonic spin waves in microscopic stripes: O. Rousseau, M. Yamada, K. Miura, S. Ogawa and Y. Otani, J. Appl. Phys. **115** (2014) 053914.

8. Effect of anisotropic spin absorption on the Hanle effect in lateral spin valves: H. Idzuchi, Y. Fukuma, S. Takahashi, S. Maekawa and Y. Otani, Phys. Rev. B **89** (2014) 081308(R).

9. Extrinsic spin Hall effects measured with lateral spin valve structures: Y. Niimi, H. Suzuki, Y. Kawanishi, Y. Omori, T. Valet, A. Fert and Y. Otani, Phys. Rev. B **89** (2014) 054401.

10. Spin Injection into a Superconductor with Strong Spin-Orbit Coupling: T. Wakamura, N. Hasegawa, K. Ohnishi, Y. Niimi and Y. Otani, Phys. Rev. Lett. **112** (2014) 036602.

† Joint research with outside partners.

Komori group

Electronic structures of Pt-induced nanowires on the Ge(001) surface were studied by ARPES. Two one-dimensional (1D) metallic surface bands are clearly identified at temperatures much lower than its structural transition temperature. This 1D system exhibits neither Peierls instability nor Luttinger liquid behaviors. The elastic-scattering vectors within the topological surface state (TSS) of a topological insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ were studied using quasiparticle interference patterns measured by STM. The results are compared by the surface band obtained using time-resolved ARPES. The scattering in the TSS is effectively prohibited in a wide angular range of 100-180°.

1. Selective doping in a surface band and atomic structures of the Ge(111) ($\sqrt{3} \times \sqrt{3}$)R30°–Au surface: K. Nakatsuji, Y. Motomura, R. Niikura and F. Komori, J. Phys.: Condens. Matter **25** (2013) 045007 (9).

2. Fabrication and characterization of strain-driven self-assembled CrN nanoislands on Cu(001): P. Krukowski, T. Iimori, K. Nakatsuji, M. Yamada and F. Komori, J. Appl. Phys. **113** (2013) 174309 (5).

3. [*]Fermi gas behavior of a one-dimensional metallic band of Pt-induced nanowires on Ge(001): K. Yaji, I. Mochizuki, S. Kim, Y. Takeichi, A. Harasawa, Y. Ohtsubo, P. Le Fevre, F. Bertran, A. Taleb-Ibrahimi, A. Kakizaki and F. Komori, Phys. Rev. B **87** (2013) 241413R (5).

4. [†]Graphene nanoribbons on vicinal SiC surfaces by molecular beam epitaxy: T. Kajiwara, Y. Nakamori, A. Visikovskiy, T. Iimori, F. Komori, K. Nakatsuji, K. Mase and S. Tanaka, Phys. Rev. B **87** (2013) 121407R (1-4).

5. Growth and structure of CrN nanoislands on Cu(001) studied by scanning tunneling microscopy and X-ray photoemission spectroscopy: P. Krukowski, T. Iimori, K. Nakatsuji, M. Yamada and F. Komori, Thin Solid Films **531** (2013) 251-254.

6. [†]Systematic study of surface magnetism in Si(111)-Fe system grown by solid phase epitaxy: In situ schematic magnetic phase diagram of Si(111)-Fe: A. N. Hattori, K. Hattori, K. Kataoka, E. Takematsu, A. Ishii, F. Komori and H. Daimon, J. Magn. Magn. Mater. **363** (2014) 158-165.

7. [*]Robust Protection from Backscattering in the Topological Insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$: S. Kim, S. Yoshizawa, Y. Ishida, K. Eto, K. Segawa, Y. Ando, S. Shin and F. Komori, Phys. Rev. Lett. **112** (2014) 136802(1-5).

8. [*]Observing hot carrier distribution in an n-type epitaxial graphene on a SiC substrate: T. Someya, H. Fukidome, Y. Ishida, R. Yoshida, T. Iimori, R. Yukawa, K. Akikubo, Sh. Yamamoto, S. Yamamoto, T. Yamamoto, T. Kanai, K. Funakubo, M. Suemitsu, J. Itatani, F. Komori, S. Shin and I. Matsuda, Appl. Phys. Lett. **104** (2014) 161103(1-4).

9. [†*]Scanning tunneling microscopic and spectroscopic studies on a crystalline silica monolayer epitaxially formed on hexagonal SiC(000-1) surfaces: H. Tochihara, T. Shirasawa, T. Suzuki, T. Miyamachi, T. Kajiwara, K. Yagyu, S. Yoshizawa, T. Takahashi, S. Tanaka and F. Komori, Appl. Phys. Lett. **104** (2014) 051601(1-4).

10. エピタキシャルグラフェンの電子状態：中辻 寛，小森 文夫，「ポストシリコン半導体 - ナノ成膜ダイナミクスと基板・界面効果 -」，6章2．2，財満　鎮明，(NTS, 東京都文京区湯島 2-16-16, 2013), 334-345.

Yoshinobu group

We conducted several research projects in the fiscal year 2013. (1) The adsorption and activation of CO_2 on Cu(997) studied by SR-PES and IRAS. (2) The adsorption and decomposition of formic acid on Cu(111) studied by SR-PES and IRAS. (3) Spectroscopic characterization and transport properties of the Si(111) native oxide surface with tetrafluorotetracyanoquinodimethane. (4) Electronic structure of alufa-sexithiophene ultra thin films grown on passivated Si(001) surfaces.

1. Energy level alignment of cyclohexane on Rh(111): the importance of interfacial dipole and final-state screening: T. Koitaya, K. Mukai, S. Yoshimoto and J. Yoshinobu, J. Chem. Phys. **138** (2013) 044702 (9 pages).

2. 巻頭言「君たちは何のために研究するのか?」：吉信 淳，表面科学 **34** (2013) 403.

3. Site-specific chemical states of adsorbed CO on Pt(997): a high resolution XPS study: S. Shimizu, H. Noritake, T. Koitaya, K. Mukai, S. Yoshimoto and J. Yoshinobu, Surf. Sci. **608** (2013) 220-225.

4. Spectroscopic Characterization and Transport Properties of Aromatic Monolayers Covalently Attached to Si(111) Surfaces: Y. Harada, T. Koitaya, K. Mukai, S. Yoshimoto and J. Yoshinobu, J. Phys. Chem. C **117** (2013) 7497-7505.

5. Quantitative analysis of chemical interaction and doping of the Si(111) native oxide surface with tetrafluorotetracyanoquinodimethane: S. Yoshimoto, M. Furuhashi, T. Koitaya, Y. Shiozawa, K. Fujimaki, Y. Harada, K. Mukai and J. Yoshinobu, J. Appl. Phys. **115** (2014) 143709.

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* Joint research among groups within ISSP.

6. †Electronic structure of α-sexithiophene ultrathin films grown on passivated Si(001) surfaces: K. Hiraga, H. Toyoshima, H. Tanaka, K. Inoue, S. Ohno, K. Mukai, J. Yoshinobu and M. Tanaka, Appl. Surf. Sci. **307** (2014) 520.

7. Aqueous-Phase Oxidation of Epitaxial Graphene on the Silicon Face of SiC(0001): Md. Zakir Hossain, M. B. A. Razak, S. Yoshimoto, K. Mukai, T. Koitaya, J. Yoshinobu, H. Sone, S. Hosaka and M. C. Hersam, J. Phys. Chem. C **118** (2014) 1014.

8. Structure and Photo-Induced Charge Transfer of Pyridine Molecules Adsorbed on TiO_2(110): A NEXAFS and Core-Hole-Clock Study: H. Kondoh, Y. Higashi, M. Yoshida, Y. Monya, R. Toyoshima, K. Mase, K. Amemiya, F. Tsukioka, M. Nagasaka, Y. Iwasawa, H. Orita, K. Mukai and J. Yoshinobu, Electrochemistry **82** (2014) 341.

9. Interface state and energy level alignment of F_4-TCNQ sandwiched between a pentacene film and the ethylene-terminated Si(100) surface: S. Yoshimoto, K. Kameshima, T. Koitaya, Y. Harada, K. Mukai and J. Yoshinobu, Organic Electronics **15** (2014) 356.

10. 淡青評論「東京大学憲章を読んでみませんか」：吉信 淳 , 学内広報 **1450** (2014) 12.

11. 「現代ケイ素化学 - 体系的な基礎概念と応用に向けて」のうち第 24 章「ケイ素単結晶表面の修飾」(p.377-p.388). : 吉良 満夫 , 玉尾皓平 (編集), 吉信淳（部分執筆）, (化学同人 , 京都市 , 2013).

12. 絶対微小　日常生活を量子論で理解する : マイケ ル・D・フェイヤー著 , 丑田 公規 , 吉信淳 訳 , (化学同人 , Kyoto, 2013).

13. 「水素の事典」のうち 5 章 1-a（p.86-p.89）を分担執筆. : 水素エ ネルギー協会編 , (朝倉書店 , 東京 , 2014).

Hasegawa group

We studied the superconducting proximity effect in real space by using low-temperature scanning tunneling microscopy and spectroscopy aiming at the observation of peculiar superconducting states, such as Fulde–Ferrell–Larkin–Ovchinnikov (FFLO) states and odd-frequency superconductivity. So far, we observed the spatial distribution of superconductivity around an interface between Pb islands and a two-dimensional (2D) diffusive normal metal, and found that the surface steps in the 2D normal metal working as a potential barrier exhibit a significant role on the proximity effect; through the real-space mapping of superconductivity in nano-meter spatial resolution, we observed the steps blocking the propagation of the proximity and enhancing it in confined area between the steps and the super/normal interface. The enhancement is explained with reflectionless tunneling, quantum interference phenomenon between the incident electrons and retro-reflected holes formed by the Andreev reflection at the interface. On a 2D surface superconductor, which can be formed by depositing 1 monolayer In or Pb on Si(111) substrate, we also observed Josephson vortices at the step edges, indicating weakened superconductivity there.

1. Trapping and squeezing of vortices in voids directly observed by scanning tunneling microscopy and spectroscopy: T. Tominaga, T. Sakamoto, H. Kim, T. Nishio, T. Eguchi and Y. Hasegawa, Phys. Rev. B **87** (2013) 195434.

2. †Microscopic origin of the π states in epitaxial silicene: A. Fleurence, Y. Yoshida, C. -C. Lee, T. Ozaki, Y. Yamada-Takamura and Y. Hasegawa, Appl. Phys. Lett. **104** (2014) 021605 (4 pages).

Lippmaa group

High-temperature growth studies of magnetite Fe_3O_4 showed that it is possible to fabricate self-organized arrays of strain-free and uniformly oriented nanoscale pyramids. We hope to use such nanopyramid arrays for studying the multiferroic coupling in magnetite. Nanoscale composite materials based on a ferromagnetic spinel, $CoFe_2O_4$ and a ferroelectric perovskite, $Bi_5Ti_3FeO_{15}$ were characterized in collaboration with our joint-use partners. Saturation magnetism and spin dilution was studied in $Pr_{0.8}Ca_{0.2}MnO_3$ to develop a suitably weak ferromagnet for use in superconductor - ferromagnet tunnel junctions. Work proceeded on the development of light-element oxide films with the mapping of the growth mechanisms of BeO.

1. Nonmagnetic Sc Substitution in a Perovskite Ferromagnetic Insulator $Pr_{0.8}Ca_{0.2}MnO_3$: T. Harada, R. Takahashi and M. Lippmaa, J. Phys. Soc. Jpn. **82** (2013) 014801(1-5).

2. Spectroscopic studies on the electronic and magnetic states of Co-doped perovskite manganite $Pr_{0.8}Ca_{0.2}Mn_{1-y}Co_yO_3$ thin films: K. Yoshimatsu, H. Wadati, E. Sakai, T. Harada, Y. Takahashi, T. Harano, G. Shibata, K. Ishigami, T. Kadono, T. Koide, T. Sugiyama, E. Ikenaga, H. Kumigashira, M. Lippmaa, M. Oshima and A. Fujimori, Phys. Rev. B **88** (2013) 174423.

3. Epitaxial $Bi_5Ti_3FeO_{15}$–$CoFe_2O_4$ Pillar–Matrix Multiferroic Nanostructures: A. Imai, X. Cheng, H. L. Xin, E. A. Eliseev, A. N. Morozovska, S. V. Kalinin, R. Takahashi, M. Lippmaa, Y. Matsumoto and V. Nagarajan, ACS Nano **7** (2013) 11079-11086.

† Joint research with outside partners.

4. Pulsed laser deposition of epitaxial BeO thin films on sapphire and $SrTiO_3$: T. Peltier, R. Takahashi and M. Lippmaa, Appl. Phys. Lett. **104** (2014) 231608(1-4).

5. Spontaneous Growth of Strain-Free Magnetite Nanocrystals via Temperature-Driven Dewetting: R. Takahashi, H. Misumi, T. Yamamoto and M. Lippmaa, Crystal Growth & Design **14** (2014) 1264-1271.

6. Combinatorial Nanoscience and Technology for Solid-state Materials: H. Koinuma, R. Takahashi, M. Lippmaa, S.-Y. Jeong, Y. Matsumoto, T. Chikyo and S. Suzuki, in: *Handbook of Advanced Ceramics*, Ch 11.1.11, edited by S. Somiya, (Academic Press, Amsterdam, 2013), 1103-1124.

Division of Physics in Extreme Conditions

Uwatoko group

The present antiferromagnetic state T_N=7.5 K of $EuBi_3$ with the $AuCu_3$-type cubic structure is found to be stable under pressures up to 8 GPa, where the Neel temperature increases with increasing pressure, being T_N=16.5 K at 8 GPa. We have studied the effect of pressure on the superconducting transition temperature of YFe_4P_{12} and $LaFe_4P_{12}$ up to 8 GPa through electrical resistivity measurements in a cubic anvil apparatus. T_{SC} of both compounds increase to 9.3 K and 8.0 K with increasing pressure, but the slopes decreases gradually with increasing pressure, respectivily. In contrast, the T_{SC} of YRu_4P_{12} and $LaRu_4P_{12}$ monotonically decreases with pressure. The distinct pressure dependences of both T_{SC} cannot be explained solely from a structural point of view. The pressure dependence of the electrical resistivity of $BaCo_2As_2$ single crystal as a function of temperature was measured up to 8 GPa. A hybrid-type piston-cylinder pressure cell for the electron spin resonance (ESR) measurement has been developed that the pressure reaches 2.1 GPa. The cylinder of this pressure cell consists of a NiCrAl inner cylinder and a CuBe outer sleeve, and all inner parts are made of zirconium oxide which has good transmittance to the millimeter and submillimeter waves. We have also developed a transmission-type high-field ESR system having two different modulation methods for this pressure cell.

1. †AC Susceptibility of the Dipolar Spin Ice $Dy_2Ti_2O_7$: Experiments and Monte Carlo Simulations: H. Takatsu, K. Goto, H. Otsuka, R. Higashinaka, K. Matsubayashi, Y. Uwaoko and H. Kadowaki, J. Phys. Soc. Jpn. **82** (2013) 104710(1-5).

2. Change in Unusual Magnetic Properties by Rh Substitution in $CeRu_2Al_{10}$: R. Kobayashi, Y. Ogane, D. Hirai, T. Nishioka, M. Matsumura, Y. Kawamura, K. Matsubayashi, Y. Uwatoko, H. Tanida and M. Sera, J. Phys. Soc. Jpn. **82** (2013) 093702(1-5).

3. †Fermi Surface and Magnetic Properties of Antiferromagnet $EuBi_3$: A. Nakamura, Y. Hiranaka, M. Hedo, T. Nakama, Y. Tatetsu, T. Maehira, Y. Miura, A. Mori, H. Tsutsumi, Y. Hirose, K. Mitamura, K. Sugiyama, M. Hagiwara, F. Honda, T. Takeuchi, Y. Haga, K. Matsubayashi, Y. Uwatoko and Y. Onuki, J. Phys. Soc. Jpn. **82** (2013) 124708(1-6).

4. †Magnetic and Fermi Surface Properties of $EuGa_4$: A. Nakamura, Y. Hiranaka, M. Hedo, T. Nakama, Y. Miura, H. Tsutsumi, A. Mori, K. Ishida, K. Mitamura, Y. Hirose, K. Sugiyama, F. Homda, R. Settai, T. Takeuchi, M. Hagiwara, T. D. Matsuda, E. Yamamoto, Y. Haga, K. Matsubayashi, Y. Uwatoko, H. Harima and Y. Onuki, J. Phys. Soc. Jpn. **82** (2013) 104703 (1-10).

5. Microscopic Evidence of a Crossover to a Low-Temperature Intermediate Valence State in $YbCo_2Zn_{20}$: T. Mito, H. Hara, T. Ishida, K. Nakagawara, T. Koyama, K. Ueda, T. Kohara, K. Ishida, K. Matsubayashi, Y. Saiga and Y. Uwatoko, J. Phys. Soc. Jpn. **82** (2013) 103704 (1-4).

6. †Pressure and Substitution Effects on Transport and Magnetic Properties of $Y_{1-x}R_xCo_2$ Systems with Static Magnetic Disorder: M. Takeda, A. Teruya, S. Watanabe, S. Hirakawa, Y. Hiranaka, A. Nakamura, Y. Takaesu, K. Uchima, M. Hedo, T. Nakama, K. Yagasaki, K. Matsubayashi, Y. Uwatoko and A. T. Burkov, J. Phys. Soc. Jpn. **82** (2013) 014708 (1-6).

7. †Two-Dimensional Monopole Dynamics in the Dipolar Spin Ice $Dy_2Ti_2O_7$: H. Takatau, K. Goto, H. Otsuka, R. Higashinaka, K. Matsubayashi, Y. Uwatoko and H. Kadowaki, J. Phys. Soc. Jpn. **82** (2013) 073707(1-5).

8. †Magnetic properties of spinel $CuCrZrS_4$ under pressure: M. Ito, N. Kado, K. Matsubayashi, Y. Uwatoko, N. Terada, S. Ebisu and S. Nagata, J. Magn. Magn. Mater. **331** (2013) 98-101.

9. Dielectric properties of single crystal spinels in the series FeV_2O_4, MnV_2O_4, and CoV_2O_4 in high magnetic fields: A. Kismarahadja, J. S. Brooks, H. D. Zhou, E. S. Choi, K. Matsubayashi and Y. Uwatoko, Phys. Rev. B **87** (2013) 054432 (1-10).

---

* Joint research among groups within ISSP.

10. High-pressure synthesis of the $BaIrO_3$ perovskite: A Pauli paramagnetic metal with a Fermi liquid ground state: J. G. Cheng, T. Ishii, H. Kojitani, K. Matsubayashi, A. Matsuo, X. Li, Y. Shirako, J. S. Zhou, J. B. Goodenough, C. Q. Jin, M. Akaogi and Y. Uwatoko, Phys. Rev. B **88** (2013) 205114(1-7).

11. Pressure dependence of the superconducting transition temperature of the filled skutterudite YFe_4P_{12}: J. G. Cheng, J. S. Jhou, K. Matsubayashi, P. P. Kong, Y. Kubo, Y. Kawamura, C. Sekine, C. Q. Jin, J. B. Goodenough and Y. Uwatoko, Phys. Rev. B **88** (2013) 024514(1-8).

12. †Development of a Low-Temperature Insert for Precise Magnetization Measurement below T = 2 K with a Superconducting Quantum Interference Device Magnetometer: Y. Sato, S. Makiyama, Y. Sakamoto, T. Hasuo, Y. Inagaki, T. Fujiwara, H. S. Suzuki, K. Matsubayashi, Y. Uwatoko and T. Kawae, Jpn. J. Appl. Phys. **52** (2013) 106702 (1-6).

13. Possible Kondo Physics near a Metal-Insulator Crossover in the A-Site Ordered Perovskite $CaCu_3Ir_4O_{12}$: J. G. Cheng, J. S. Zhou, Y. F. Yang, H. D. Zhou, K. Matsubayashi, Y. Uwatoko, A. MacDonald and J. B. Goodnough, Phys. Rev. Lett. **111** (2013) 176403(1-5).

14. †*High Field Magnetization of $TbPd_2Ge_2$ Single Crystal: T. Shigeoka, T. Hasegawa, T. Fujiwara, A. Kondo, K. Kindo and Y. Uwatoko, J. Low Temp. Phys. **170** (2013) 248-254.

15. †Magnetic penetration depth and flux-flow resistivity measurements on $NaFe_{0.97}Co_{0.03}As$ single crystals: T. Okada, H. Takahashi, Y. Imai, K. Kitagawa, K. Matsubayashi, Y. Uwatoko and A. Maeda, Physica C **494** (2013) 109-112.

16. *Hydrostatic pressure (8GPa) dependence of electrical resistivity of $BaCo_2As_2$ single crystal: C. Ganguli, K. Matsubayashi, K. Ohgushi, Y. Uwatoko, M. Kanagaraj and S. Arumugam, Mat. Res. Bull. **48** (2013) 4329-4331.

17. †Magnetic and Structural Properties of $Mn_{1.8}Co_{0.2}Sb$ under High Magnetic Fields: H. Orihashi, M. Hiroi, Y. Mitsui, K. Takahashi, K. Watanabe, K. Matsubayashi, Y. Uwatoko and K. Koyama, Mater. Trans. **54** (2013) 969-973.

18. †Low energy excitations inside the vortex core of LiFe(As, P) single crystals investigated by microwave-surface impedance: T. Okada, H. Takahashi, Y. Imai, K. Kitagawa, K. Matsubayashi, Y. Uwatoko and A. Maeda, Physica C: Superconductivity **484** (2013) 27.

19. †Development of Hybrid-Type Pressure Cell for High-Pressure and High-Field ESR Measurement: K. Fujimoto, T. Sakurai, S. Okubo, H. Ohta, K. Matsubayashi, Y. Uwatoko and Y. Koike, Applied Magnetic Resonance **44** (2013) 893-898.

20. †Magnetic properties of $Mn_2Sb_{1-x}Ge_x$($0.05 \leq \leq 0.2$) in high magnetic fields: D. Shimada, H. Orihashi, D. Mitsunaga, M. Ito, M. Hiroi, K. Koyama, R. Onodera, K. Takahashi, K. Matsubayashi and Y. Uwatoko, J. Kor. Phys. Soc. **63** (2013) 743-746.

21. †Phase diagram and transport properties of $Y_{1-x}Nd_xCo_2$ pseudo-binary alloys: A. T. Burkov, M. Takeda, A. Teruya, S. Watanabe, S. Hirakawa, Y. Hiranaka, A. Nakamura, M. Hedo, T. Nakama, K. Yagasaki, Y. Takaesu, K. Uchima and Y. Uwatoko, J. Kor. Phys. Soc. **62** (2013) 2080-2083.

22. †Successive magnetic transitions of $PrRh_2$ single crystals: Y. Okawara, J. W. Cui, T. Fujiwara, T. Shigeoka, K. Matsubayashi, Y. Uwatoko, S. Kimura and K. Watanabe, J. Kor. Phys. Soc. **63** (2013) 743-746.

23. Pressure Effect on the Structure and Superconducting Transition Temperature of Filled Skutterudites LaT_4P_{12} (T=Fe, Ru): Y. Kawamura, T. Kawaai, J. Hayashi, C. Sekine, H. Gotou, J. Cheng, K. Matsubayashi and Y. Uwatoko, J. Phys. Soc. jpn. **82** (2013) 114702(1-4).

24. †Development of High-Field ESR System Using SQUID Magnetometer and its Application to Measurement under High Pressure: T. Sakurai, K. Fujimoto, S. Okubo, H. Ohata and Y. Uwatoko, Journal of Magnetics **18** (2013) 168-172.

25. *High-pressure effects in anti-post-perovskite superconductors V_3PnN_x (Pn = P, As): B. S. Wang, J. -G. Cheng, K. Matsubayashi, Y. Uwatoko and K. Ohgushi, Phys. Rev. B **89** (2014) 144510 (1-4).

26. Long-range antiferromagnetic order in the frustrated XY pyrochlore antiferromagnet $Er_2Ge_2O_7$: X. Li, W. M. Li, K. Matsubayashi, Y. Sato, C. Q. Jin, Y. Uwatoko, T. Kawae, A. M. Hallas, C. R. Wiebe, A. M. Arevalo-Lopez, J. P. Attfield, J. S. Gardner, R. S. Freitas, H. D. Zhou and J. -G. Cheng, Phys. Rev. B **89** (2014) 064409 (1-7).

27. †Magnetic Field Effect on Magnetic and Electrical Properties of$Mn_{2-x}Cu_xSb$: Y. Matsumoto, H. Orihashi, K. Matsubayashi, Y. Uwatoko, M. Hiroi and K. Koyama, IEEE Transactions on Magnetics **50** (2014) 1000704(1-4).

28. *Heavy fermion superconductivity under pressure in the quadrupole system $PrTi_2Al_{20}$: K. Matsubayashi, T. Tanaka, J. Suzuki, A. Sakai, S. Nakatsuji, K. Kitagawa, Y. Kubo and Y. Uwatoko, J. Phys. Soc. Jpn. (2014), in print.

† Joint research with outside partners.

Osada group

In an organic Dirac fermion system α-(BEDT-TTF)$_2$I$_3$, the ν=0 quantum Hall state is realized under magnetic fields resulting from the breaking of four-fold (spin and valley) degeneracy of the singular n=0 Landau level.. The recent NMR measurement has suggested the possible transition from the quantum Hall ferromagnetic (QHF) phase to the quantum Hall insulator (QHI) phase around 15 T. To check this possibility, we have performed high-field transport measurement up to 31T using the NHMFL at Tallahassee, USA. The interlayer resistance shows the saturating behavior up to high fields, which reflects the surface transport via helical edge state of the QHF phase. We can see no anomaly in the saturating region, especially around 15T. This result means that the QHF state survives up to 31T with no QHF-QHI transition.

1. Angle-Dependent Magnetoresistance Oscillations and Charge Density Wave in the Organic Conductor α-(BEDT-TTF)$_2$KHg(SCN)$_4$: K. Uchida, R. Yamaguchi, T. Konoike, T. Osada and W. Kang, J. Phys. Soc. Jpn. **82** (2013) 043714(1-4).
2. Anomalous Thermoelectric Transport and Giant Nernst Effect in Multilayered Massless Dirac Fermion System: T. Konoike, M. Sato, K. Uchida and T. Osada, J. Phys. Soc. Jpn. **82** (2013) 073601(1-4).
3. †Stereoscopic study of the angle-dependent magnetoresistance oscillations across the charge-density-wave transition of the organic conductor α-(BEDT-TTF)$_2$KHg(SCN)$_4$: W. Kang, T. Osada, T. Konoike and K. Uchida, Phys. Rev. B **88** (2013) 195105(1-9).
4. 強磁場下電気伝導に現れるサイクロトロン共鳴：長田 俊人，熊谷 篤，内田 和人，鴻池 貴子，固体物理 **48** (2013) 65-73.
5. 角度依存シュタルクサイクロトロン共鳴とその応用：鴻池 貴子，パリティ **28(4)** (2013) 42-45.
6. 角度依存シュタルクサイクロトロン共鳴法の開発：長田 俊人，パリティ **28(1)** (2013) 20-23.
7. 有機ディラック電子系における量子ホール状態：田嶋 尚也，佐藤 光幸，鴻池 貴子，長田 俊人，固体物理 **49** (2014) 229-240.

Yamashita group

As the first year of Yamashita group, we developed a new probe for thermal-Hall measurement which can be used in VTI system with 16 T magnet. With this probe, we successfully started the study of thermal-transport measurement of a kagomé material, Volborthite, to find if there is a thermal-Hall effect due to spinons. Developments of the measurement systems for studies under ultra-low temperatures, on the other hand, did not work out due to malfunctions of dilution refrigerators inherited from Ishimoto and Tajima groups.

Materials Design and Characterization Laboratory

Hiroi group

Spinodal decomposition is a ubiquitous phenomenon leading to phase separation from a uniform solution. We show that a spinodal decomposition occurs in a unique combination of two rutile compounds of TiO_2 and VO_2, which are chemically and physically distinguished from each other: TiO_2 is a wide-gap insulator with photo catalytic activities and VO_2 is assumed to be a strongly correlated electron system which exhibits a dramatic metal-insulator transition at 342 K. The spinodal decomposition takes place below 830 K at a critical composition of 34 mol% Ti, generates a unidirectional composition modulation along the c axis with a wavelength of approximately 6 nm, and finally results in the formation of self-assembled lamella structures made up of Ti-rich and V-rich layers stacked alternately with 30-50 nm wavelengths. A metal-insulator transition is not observed in quenched solid solutions with intermediate compositions but emerges in the thin V-rich layers as the result of phase separation. Interestingly, the metal-insulator transition remains as sharp as in pure VO_2 even in such thin layers and takes place at significantly reduced temperatures of 310-340 K, which is probably due to a large misfit strain induced by lattice matching at the coherent interface.

1. *Magnetic Order in the Spin-1/2 Kagome Antiferromagnet Vesignieite: M. Yoshida, Y. Okamoto, M. Takigawa and Z. Hiroi, J. Phys. Soc. Jpn. **82** (2013) 013702(1-5).
2. Magnetic Properties of the Spin-1/2 Deformed Kagome Antiferromagnet Edwardsite: H. Ishikawa, Y. Okamoto and Z. Hiroi, J. Phys. Soc. Jpn. **82** (2013) 063710.

* Joint research among groups within ISSP.

3. Pressure Effects on Rattling and Superconductivity in the Einstein Solids: Y. Ikeda, Y. Kawasaki, T. Shinohara, S. Araki, T. C. Kobayashi, A. Onosaka, Y. Okamoto, J.-I. Yamaura and Z. Hiroi, J. Phys. Soc. Jpn. **82** (2013) 063707.

4. Understanding of the Temperature–Pressure Phase Diagram of β-Pyrochlore Oxides: A Role of Anhamonicity on Superconductivity: T. Isono, D. Iguchi, T. Matsubara, Y. Machida, B. Salce, J. Flouquet, H. Ogusu, J.-I. Yamaura, Z. Hiroi and K. Izawa, J. Phys. Soc. Jpn. **82** (2013) 114708.

5. YCr_6Ge_6 as a Candidate Compound for a Kagome Metal: Y. Ishii, H. Harima, Y. Okamoto, J.-I. Yamaura and Z. Hiroi, J. Phys. Soc. Jpn. **82** (2013) 023705(1-4).

6. Breathing Pyrochlore Lattice Realized in A-Site Ordered Spinel Oxides $LiGaCr_4O_8$ and $LiInCr_4O_8$: Y. Okamoto, G. J. Nilsen, J. Paul Attfield and Z. Hiroi, Phys. Rev. Lett. **110** (2013) 097203(1-5).

7. *5d 遷移金属パイロクロア酸化物における低温磁気構造の研究：山浦 淳一，大串 研也，広井 善二，日本結晶学会誌 **55** (2013) 116-120.

8. *Spinodal Decomposition in the TiO_2–VO_2 System: Z. Hiroi, H. Hayamizu, T. Yoshida, Y. Muraoka, Y. Okamoto, J.-I. Yamaura and Y. Ueda, Chem. Mater. **25** (2013) 2202.

9. †*Iseite, $Mn_2Mo_3O_8$, a new mineral from Ise, Mie Prefecture, Japan: D. Nishio-Hamane, N. Tomita, T. Minakawa and S. Inaba, Journal of Mineralogical and Petrological Sciences **108** (2013) 37-41.

10. †*Synthesis of $LiNi_{0.5}Mn_{1.5}O_4$ and $0.5Li_2MnO_3$–$0.5LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ hollow nanowires by electrospinning: E. Hosono, T. Saito, J. Hoshino, Y. Mizuno, M. Okubo, D. Asakura, K. Kagesawa, D. Nishio-Hamane, T. Kudo and H. Zhou, CrystEngComm **15** (2013) 2592-2597.

11. *Electronic State of $CeFe_4As_{12}$ Investigated by Using Single Crystals Grown under High Pressure of 4 GPa: Y. Ogawa, H. Sato, M. Watanabe, T. Namiki, S. Tatsuoka, R. Higashinaka, Y. Aoki, K. Kuwahara, J.-I. Yamaura and Z. Hiroi, J. Phys. Soc. Jpn. **83** (2014) 034710.

12. *Kagome–Triangular Lattice Antiferromagnet $NaBa_2Mn_3F_{11}$: H. Ishikawa, T. Okubo, Y. Okamoto and Z. Hiroi, J. Phys. Soc. Jpn. **83** (2014) 043703(1-5).

Kawashima group

We have been investigating quantum spin/boson systems and frustrated systems by means of large-scale numerical simulation. We also develop new numerical techniques. Our group's achievements of 2013 include: (1) clarifying the apparent deconfined critical behavior of the SU(N) J-Q Heisenberg model with a strong corrections to scaling, (2) lattice rotational symmetry breaking in flustrated spin systems, and (3) highly parallelized code for the molecular dynamics simulation of mixed-phase fluid dynamics.

1. Mott Transition of Bose–Fermi Mixtures in Optical Lattices Induced by Attractive Interactions: A. Masaki and H. Mori, J. Phys. Soc. Jpn. **82** (2013) 074002(1-4).

2. *Possibility of deconfined criticality in SU(N) Heisenberg models at small N: K. Harada, T. Suzuki, T. Okubo, H. Matsuo, J. Lou, H. Watanabe, S. Todo and N. Kawashima, Phys. Rev. B **88** (2013) 220408(1-4).

3. Second-order phase transition in the Heisenberg model on a triangular lattice with competing interactions: R. Tamura, S. Tanaka and N. Kawashima, Phys. Rev. B **87** (2013) 214401(1-5).

4. †*Various regimes of quantum behavior in an S=1/2 Heisenberg antiferromagnetic chain with fourfold periodicity: H. Yamaguchi, T. Okubo, K. Iwase, T. Ono, Y. Kono, S. Kittaka, T. Sakakibara, A. Matsuo, K. Kindo and Y. Hosokoshi, Phys. Rev. B **88** (2013) 174410(1-5).

5. Visibility pattern of Bose–Fermi mixtures in one-dimensional incommensurate lattices: A. Masaki and H. Mori, Philosophical Magazine Letters **93** (2013) 422(9pages).

6. Fermion-induced decoherence of bosons in optical lattices: A. Masaki and H. Mori, J. Phys.: Conf. Ser. **454** (2013) 012048(1-4).

7. Huge-scale molecular dynamics simulation of multibubble nuclei: H. Watanabe, M. Suzuki and N. Ito, Computer Physics Communications **184** (2013) 2775(8pages).

8. *Kagome–Triangular Lattice Antiferromagnet $NaBa_2Mn_3F_{11}$: H. Ishikawa, T. Okubo, Y. Okamoto and Z. Hiroi, J. Phys. Soc. Jpn. **83** (2014) 043703(1-5).

† Joint research with outside partners.

9. Parallelized Quantum Monte Carlo Algorithm with Nonlocal Worm Updates: A. Masaki-Kato, T. Suzuki, K. Harada, S. Todo and N. Kawashima, Phys. Rev. Lett. **112** (2014) 140603(1-5).

10. Phase Transitions with Discrete Symmetry Breaking in Antiferromagnetic Heisenberg Models on a Triangular Lattice: R. Tamura, S. Tanaka and N. Kawashima, JPS Conf. Proc. --- Proceedings of the 12th Asia Pacific Physics Conference (APPC12) **1** (2014) 012125(1-5).

Noguchi group

We have studied the structure formation of surfactant membranes under shear flow. We found that shear can induce a rolled lamellae structure, which structure factor agrees with those of intermediate states during lamellar-to-onion transition measured by time-resolved scatting experiments. We revealed that entropy reduction of membrane fluctuations can induce aggregation of binding proteins in multilamellar membranes. We also studied the effects of anchored polymers on membranes and dynamics of deformable active particles.

1. Dynamics of a deformable active particle under shear flow: M. Tarama, A. M. Menzel, B. T. Hagen, R. Wittkowski, T. Ohta and H. Loewen, J. Chem. Phys. **139** (2013) 104906.

2. Spatiotemporal heterogeneity of local free volumes in highly supercooled liquid: H. Shiba and T. Kawasaki, J. Chem. Phys. **139** (2013) 184502.

3. Structure formation in binary mixtures of lipids and detergents: Self-assembly and vesicle division: H. Noguchi, J. Chem. Phys. **138** (2013) 024907(1-9).

4. Structure formation of surfactant membranes under shear flow: H. Shiba, H. Noguchi and G. Gompper, J. Chem. Phys. **139** (2013) 014702.

5. Oscillatory motions of an active deformable particle: M. Tarama and T. Ohta, Phys. Rev. E **87** (2013) 062912.

6. Mechanical properties and microdomain separation of fluid membranes with anchored polymers: H. Wu, H. Shiba and H. Noguchi, Soft Matter **9** (2013) 9907.

7. Effects of anchored flexible polymers on mechanical properties of model biomembranes: H. Wu and H. Noguchi, AIP Conf. Proc. **1518** (2013) 649-653.

8. Hierarchical heterogeneous glassy dynamics of configuration changes and vibration modes: T. Kawasaki, H. Shiba and A. Onuk, AIP Conf. Proc. **1518** (2013) 784-791.

9. Structure formation of lipid membranes: Membrane self-assembly and vesicle opening-up to octopus-like micelles: H. Noguchi, AIP Conf. Proc. **1518** (2013) 566-570.

10. 脂質膜の構造形成の粗視化シミュレーション：野口 博司 , 生物物理 **53** (2013) 11-14.

11. Entropy-driven aggregation in multilamellar membranes: H. Noguchi, EPL **102** (2013) 68001.

12. 粒子描像の流体力学計算手法 I: 野口 博司 , 分子シミュレーション研究会会誌 “アンサンブル ” **15** (2013) 265-268.

13. Morphological variation of a lipid vesicle confined in a spherical vesicle: A. Sakashita, M. Imai and H. Noguchi, Phys. Rev. E **89** (2014) 040701.

14. Multiscale modeling of blood flow: from single cells to blood rheology: D. A. Fedosov, H. Noguchi and G. Gompper, Biomech. Model. Mechanobiol. **13** (2014) 239-258.

15. 界面活性剤系の構造形成の粗視化分子シミュレーション：芝隼 人 , 野口 博司 , 分子シミュレーション研究会会誌 “アンサンブル ” **16** (2014) 59-65.

16. 粒子描像の流体力学計算手法 II: 野口 博司 , 分子シミュレーション研究会会誌 “アンサンブル ” **16(2)** (2014) 118-121.

Materials Synthesis and Characterization group

1. †*Iseite, $Mn_2Mo_3O_8$, a new mineral from Ise, Mie Prefecture, Japan: D. Nishio-Hamane, N. Tomita, T. Minakawa and S. Inaba, Journal of Mineralogical and Petrological Sciences **108** (2013) 37-41.

* Joint research among groups within ISSP.

2. †Takanawaite-(Y), a new mineral of the M-type polymorph with $Y(Ta,Nb)O_4$ from Takanawa Mountain, Ehime Prefecture, Japan: D. Nishio-Hamane, T. Minakawa and Y. Ohgoshi, Journal of Mineralogical and Petrological Sciences **108** (2013) 335.

3. †*Synthesis of $LiNi_{0.5}Mn_{1.5}O_4$ and $0.5Li_2MnO_3$–$0.5LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ hollow nanowires by electrospinning: E. Hosono, T. Saito, J. Hoshino, Y. Mizuno, M. Okubo, D. Asakura, K. Kagesawa, D. Nishio-Hamane, T. Kudo and H. Zhou, CrystEngComm **15** (2013) 2592-2597.

4. †VGCF-core@$LiMn_{0.4}Fe_{0.6}PO_4$-sheath heterostructure nanowire for high rate Li-ion batteries: K. Kagesawa, E. Hosono, M. Okubo, J. Kikkawa, D. Nishio-Hamane, T. Kudo and H. Zhou, CrystEngComm **15** (2013) 6638.

5. †Spin transition and substitution of Fe^{3+} in Al-bearing post-Mg-perovskite: K. Fujino, D. Nishio-Hamane, Y. Kuwayama, N. Sata, S. Murakami, M. Whitaker, A. Shinozaki, H. Ohfuji, Y. Kojima, T. Irifune, N. Hiraoka, H. Ishii and K.-D. Tsuei, Physics of the Earth and Planetary Interiors **217** (2013) 31.

6. Minohlite, a new copper-zinc sulfate mineral from Minoh, Osaka, Japan: M. Ohnishi, N. Shimobayashi, D. Nishio-Hamane, K. Shinoda, K. Momma and T. Ikeda, Mineral. Mag. **77** (2013) 335.

7. †Vanadoallanite-(La): a new epidote-supergroup mineral from Ise, Mie Prefecture, Japan: M. Nagashima, D. Nishio-Hamane, N. Tomita, T. Minakawa and S. Inaba, Mineral. Mag. **77** (2013) 2739.

8. *Electronic State of $CeFe_4As_{12}$ Investigated by Using Single Crystals Grown under High Pressure of 4 GPa: Y. Ogawa, H. Sato, M. Watanabe, T. Namiki, S. Tatsuoka, R. Higashinaka, Y. Aoki, K. Kuwahara, J.-I. Yamaura and Z. Hiroi, J. Phys. Soc. Jpn. **83** (2014) 034710.

9. †Magnetic properties of Mn–Bi melt-spun ribbons: T. Saito, R. Nishimura and D. Nishio-Hamane, J. Magn. Magn. Mater. **349** (2014) 9.

10. †Successive phase transitions driven by orbital ordering and electron transfer in quasi-two-dimensional $CrSe_2$ with a triangular lattice: S. Kobayashi, H. Ueda, D. Nishio-Hamane, C. Michioka and K. Yoshimura, Phys. Rev. B **89** (2014) 054413.

11. Iwateite, $Na_2BaMn(PO_4)_2$, a new mineral from the Tanohata mine, Iwate Prefecture, Japan: D. Nishio-Hamane, T. Minakawa and H. Okada, Journal of Mineralogical and Petrological Sciences **109** (2014) 34.

12. †Magnetic properties of $SmCo_{5-x}Fe_x$ (x=0–4) melt-spun ribbon: T. Saito and D. Nishio-Hamane, J. Alloys Compd. **585** (2014) 423.

13. †Electrochemical properties of $LiMn_xFe_{1-x}PO_4$ (x = 0, 0.2, 0.4, 0.6, 0.8 and 1.0)/vapor grown carbon fiber core–sheath composite nanowire synthesized by electrospinning method: K. Kagesawa, E. Hosono, M. Okubo, D. Nishio-Hamane, T. Kudo and H. Zhou, Journal of Power Sources **248** (2014) 615.

14. †Electrically Conductive and Mechanically Elastic Titanium Nitride Ceramic Microsprings: S. Yang, X. Chen, K. Yamamoto, M. Iitake, D. Nishio-Hamane, H. Sakai and M. Abe, J. Nanosci. Nanotech. **14** (2014) 4292.

15. †Ultrafast hydrothermal synthesis of Pr-doped $Ca_{0.6}Sr_{0.4}TiO_3$ red phosphor nanoparticles using corrosion resistant microfluidic devices with Ti-lined structure under high-temperature and high-pressure condition: K. Sue, T. Ono, Y. Hakuta, H. Takashima, D. Nishio-Hamane, T. Sato, M. Ohara, M. Aoki, Y. Takebayashi, S. Yoda, T. Hiaki and T. Furuya, Chemical Engineering Journal **239** (2014) 360.

Neutron Science Laboratory

Shibayama group

Shibayama group has been exploring the structure and dynamics of soft matter, especially polymer gels, micelles, and phenolic resin, utilizing a combination of small-angle neutron scattering (SANS), neutron spin echo (NSE), and dynamic light scattering (DLS). The objectives are to elucidate the mysterious relationship between the structure and variety of novel properties/functions of polymer gels/resins. The highlights of 2012 include (1) structural analysis of high performance ion-gel comprising tetra-PEG networks, (2) atomistic molecular dynamics study of cross-linked phenolic resins, (3) rubber elasticity for incomplete polymer networks, (4) kinetic study for AB-type coupling reaction of tetra-arm polymers, (5) optimization of the thickness of a ZnS/(LiF)-Li-6 scintillator for a high-resolution detector installed on a focusing small-angle neutron scattering spectrometer (SANS-U), and so on.

1. Self-oscillating micelles: T. Ueki, M. Shibayama and R. Yoshida, Chem. Commun. **49** (2013) 6947.

† Joint research with outside partners.

2. Gelation process of Tetra-PEG ion-gel investigated by time-resolved dynamic light scattering: H. Asai, K. Nishi, T. Hiroi, K. Fujii, T. Sakai and M. Shibayama, Polymer **54** (2013) 1160.

3. Communication: Collective dynamics of room-temperature ionic liquids and their Li ion solutions studied by high-resolution inelastic X-ray scattering: K. Fujii, M. Shibayama, T. Yamaguchi, K. Yoshida, T. Yamaguchi, S. Seki, H. Uchiyama, A. Q. R. Baron and Y. Umebayashi, J. Chem. Phys. **138** (2013) 151101.

4. Correlation between Local and Global Inhomogeneities of Chemical Gels: M. Asai, T. Katashima, U.-I. Chung, T. Sakai and M. Shibayama, Macromolecules **46** (2013) 9772.

5. SANS and DLS Study of Tacticity Effects on Hydrophobicity and Phase Separation of Poly(*N* -isopropylacrylamide): K. Nishi, T. Hiroi, K. Hashimoto, K. Fujii, Y.-S. Han, T.-H. Kim, Y. Katsumoto and M. Shibayama, Macromolecules **46** (2013) 6225.

6. Solvation Structure of Poly(ethylene glycol) in Ionic Liquids Studied by High-energy X-ray Diffraction and Molecular Dynamics Simulations: H. Asai, K. Fujii, K. Nishi, T. Sakai, K. Ohara, Y. Umebayashi and M. Shibayama, Macromolecules **46** (2013) 2369.

7. Structural Study on the UCST-Type Phase Separation of Poly(*N* -isopropylacrylamide) in Ionic Liquid: H. Asai, K. Fujii, T. Ueki, S. Sawamura, Y. Nakamura, Y. Kitazawa, M. Watanabe, Y.-S. Han, T.-H. Kim and M. Shibayama, Macromolecules **46** (2013) 1101.

8. Br nsted Basicity of Solute Butylamine in an Aprotic Ionic Liquid Investigated by Potentiometric Titration: K. Fujii, K. Hashimoto, T. Sakai, Y. Umebayashi and M. Shibayama, Chem. Lett. **42** (2013) 1250.

9. Dynamic light scattering microscope: Accessing opaque samples with high spatial resolution: T. Hiroi and M. Shibayama, Opt. Express **21** (2013) 20260.

10. Gelation and cross-link inhomogeneity of phenolic resins studied by ^{13}C-NMR spectroscopy and small-angle X-ray scattering: A. Izumi, T. Nakao and M. Shibayama, Soft Matter **9** (2013) 4188.

11. Specific Solvation of Benzyl Methacrylate in 1-Ethyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)amide Ionic Liquid: M. Matsugami, K. Fujii, T. Ueki, Y. Kitazawa, Y. Umebayashi, M. Watanabe and M. Shibayama, Anal. Sci. **29** (2013) 311.

12. Acid–base property of protic ionic liquid, 1-alkylimidazolium bis(trifluoromethanesulfonyl)amide studied by potentiometric titration: K. Hashimoto, K. Fujii and M. Shibayama, Journal of Molecular Liquids **188** (2013) 143.

13. Small-Angle Neutron Scattering Study on Aggregation of 1-Alkyl-3-methylimidazolium Based Ionic Liquids in Aqueous Solution: T. Kusano, K. Fujii, M. Tabata and M. Shibayama, J Solution Chem **42** (2013) 1888.

14. Multiscale Dynamics of Inhomogeneity-Free Polymer Gels: T. Hiroi, M. Ohl, T. Sakai and M. Shibayama, Macromolecules **47** (2014) 763.

15. Small-Angle Neutron Scattering Study on Defect-Controlled Polymer Networks: K. Nishi, H. Asai, K. Fujii, Y.-S. Han, T.-H. Kim, T. Sakai and M. Shibayama, Macromolecules **47** (2014) 1801.

16. SANS および SAXS によるフェノール樹脂硬化物の構造解析：和泉 篤士 , 中尾 俊夫 , 岩瀬 裕希 , 柴山 充弘 , 波紋 **24** (2014) 11-14.

17. 中性子散乱を用いた構造解析手法　概説とエラストマー・高分子ゲル解析への応用： 柴山 充弘 , ゴム協会編 (2014) 1-10.

18. SANS studies on catalyst ink of fuel cell: M. Shibayama, T. Matsunaga, T. Kusano, K. Amemiya, N. Kobayashi and T. Yoshida, J. Appl. Polym. Sci. **131** (2014) 1-7.

19. 中性子による材料評価・構造解析：柴山 充弘 , 表面科学 **33** (2013) 258-263.

20. 小角 X 線散乱法によるフェノール樹脂ゲル化メカニズムの解析：和泉 篤士 , 中尾 俊夫 , 柴山 充弘 , ネットワークポリマー **34** (2013) 330-335.

21. 溶液中での重水素化ノボラックのコンフォメーション：和泉 篤士 , 中尾 俊夫 , 柴山 充弘 , ネットワークポリマー **33** (2013) 204-208.

22. 水面をかけ抜けるには？：東 昭 , 柴山 充弘 , 増淵 雄一 , ニュートンプレス　(2013) 90-95.

23. 中性子小角散乱を用いた分子集合体の解析：草野 巧巳 , 柴山 充弘 , Colloid & Interface Communication **39** (2014) 16-18.

* Joint research among groups within ISSP.

24. Fabrication, Structure, Mechanical Properties, and Application of Tetra-PEG Hydrogels Oren Scherman and Xian Jun Loh, Eds.: M. Shibayama and T. Sakai, in: *Polymeric and Self Assembled Hydrogels: Fundamentals to Applications, Chapt. 2*, edited by RSC Publishing, (RSC Publishing, 2013), 2-38.

25. Computer simulation of network formation in natural rubber (NR): T. Nakao and S. Kohjiya, in: *Chemistry, Manufacture and Applications of Natural Rubber, Kohjiya S. and Ikeda, Y. Eds.*, edited by S. Kohjiya and Y. Ikeda, (Woodhead, Cambridge, UK, 2014), 216-246.

Yoshizawa group

A systematic study on spin dynamics in two-dimensional transition-metal oxides has been carried out with use of the high resolution chopper spectrometer installed at BL12 in the Material and Life Science Facility, J-PARC. In the highly hole-doped region in the layered nickelate, it shows a checkerboard-type spin-charge ordering, and the nature of the excitation spectra changes its character and approaches to the metal-like behavior. Spin fluctuations in several quantum spin systems were also studied.

1. †*Long-range order and spin-liquid states of polycrystalline $Tb_{2+x}Ti_{2-x}O_{7+y}$: T. Taniguchi, H. Kadowaki, H. Takatsu, B. Fåk, J. Ollivier, T. Yamazaki, T. J. Sato, H. Yoshizawa, Y. Shimura, T. Sakakibara, T. Hong, K. Goto, L. R. Yaraskavitch and J. B. Kycia, Phys. Rev. B **87** (2013) 060408R(1-5).

2. Structural and magnetic properties in the quantum S=1/2 dimer system $Ba_3(Cr_{1-x}V_x)_2O_8$ with site disorder: T. Hong, L. Y. Zhu, X. Ke, V. O. Garlea, Y. Qiu, Y. Nambu, H. Yoshizawa, M. Zhu, G. E. Granroth, A. T. Savici, Z. Gai and H. D. Zhou, Phys. Rev. B **87** (2013) 144427(1-9).

3. Magnetic structure of the conductive triangular-lattice antiferromagnet $PdCrO_2$: H. Takatsu, G. Nénert, H. Kadowaki, H. Yoshizawa, M. Enderle, S. Yonezawa, Y. Maeno, J. Kim, N. Tsuji, M. Takata, Y. Zhao, M. Green and C. Broholm, Phys. Rev. B **89** (2014) 104408.

Yamamuro group

Our laboratory is studying chemical physics of complex condensed matters by using neutron scattering, X-ray diffraction, calorimetric, dielectric, and viscoelastic techniques. Our target materials are glasses, liquids, and various disordered systems. This year, there were two important outcomes in the study of ionic liquids. The first one, which was found in the quasielastic neutron scattering (QENS) and viscoelastic measurements, is that the inter-ionic motion is directly associated with the glass transitions in imidazolium-bases ionic liquids. The second one is that the origin of the low-Q diffraction peak, which is a typical property of the ionic liquids, is a local structure similar to that of a liquid-crystalline (SmA) phase. This was obtained from differential scanning calorimetry (DSC) and X-ray diffraction experiments. In the QENS study of a porous coordination polymer MIL-53, we have found that protons are carried by both water and ammonia molecules which are more mobile than those in bulk states. Other than these topics, we have made some progresses in the studies on palladium hydrides and vapor-deposited simple molecular glasses.

1. Phase Transition and Dynamics of Water Confined in Hydroxyethyl Copper Rubeanate Hydrate: T. Yamada, T. Yamada, M. Tyagi, M. Nagao, H. Kitagawa and O. Yamamuro, J. Phys. Soc. Jpn. **82** (2013) SA010 (8 pages).

2. Hyperfine structure of magnetic excitations in a novel Tb based single molecule magnet studied by high-resolution neutron spectroscopy: M. Kofu, T. Kajiwara, M. Nakano, K. Nakajima, S. Ohira-Kawamura, T. Kikuchi, Y. Inamura and O. Yamamuro, Phys. Rev. B **88** (2013) 064405 (7 pages).

3. Heterogeneous Slow Dynamics of Imidazolium Based Ionic Liquids Studied by Neutron Spin Echo: M. Kofu, M. Nagao, T. Ueki, Y. Kitazawa, Y. Nakamura, S. Sawamura, M. Watanabe and O. Yamamuro, J. Phys. Chem. B **117** (2013) 2773-2781.

4. Mode distribution analysis of quasi-elastic neutron scattering and application to liquid water: T. Kikuchi, K. Nakajima, S. Ohira-Kawamura, Y. Inamura, O. Yamamuro, M. Kofu, Y. Kawakita, K. Suzuya, M. Nakamura and M. Arai, Phys. Rev. E **87** (2013) 062314 (8 pages).

5. Magnetic relaxations in a Tb-based single molecule magnet studied by quasielastic neutron scattering: M. Kofu, T. Kajiwara, J. S. Gardner, G. G. Simeoni, M. Tyagi, K. Nakajima, S. Ohira-Kawamura, M. Nakano and O. Yamamuro, Chem. Phys. **427** (2013) 147-152.

6. Linear trinuclear Zn(II)–Ce(III)–Zn(II) complex which behaves as a single-molecule magnet: S. Hino, M. Maeda, K. Yamashita, Y. Kataoka, M. Nakano, T. Yamamura, H. Nojiri, M. Kofu, O. Yamamuro and T. Kajiwara, Dalton Trans. **42** (2013) 2683-2686.

† Joint research with outside partners.

7. Thermal behaviour, structure and dynamics of low-temperature water confined in mesoporous organosilica by differential scanning calorimetry, X-ray diffraction and quasi-elastic neutron scattering: M. Aso, K. Ito, H. Sugino, K. Yoshida, T. Yamada, O. Yamamuro, S. Inagaki and T. Yamaguchi, Pure and Appl. Chem. **85** (2013) 289-305.

8. Relationship between the local dynamics and gas permeability of polyacetylenes containing polymethylated indan/tetrahydronaphtalene moieties: R. Inoue, T. Kanaya, Y. Hu, T. Masuda, K. Nishida and O. Yamamuro, Polymer **55** (2014) 182-186.

9. Proton Dynamics of Two Dimensional Oxalate-Bridged Coordination Polymers: S. Miyatsu, M. Kofu, A. Nagoe, T. Yamada, M. Sadakiyo, T. Yamada, H. Kitagawa, M. Tyagi, V. Garcia Sakai and O. Yamamuro, Phys. Chem. Chem. Phys. (2014), accepted for publication.

10. 連載講座「中性子散乱による原子・分子のダイナミクスの観測」III 原子・分子のダイナミクス「液体・非晶質・表面／界面」：山室 修 , RADIOISOTOPES **62** (2013) 691-701.

Masuda group

Recently the discovery of the multiferroics, i.e., enhanced simultaneous orders in magnetism and dielectricity,revived the study of the magnetoelectric effect. A number of studies had revealed its mechanism and clarified the relationships between dielectric and magnetic structures in homogeneous systems. Next challenge would be to find and study a new magnetoelectric effect in inhomogeneous system. A remarkable example in an inhomogeneous system is a magnet having relaxor property, relaxor magnet. In 2013 our group studied a new relaxor magnet, $LuFeCoO_4$, by combination of bulk properties measurements and neutron diffraction technique. Our study reveals a novel relationship between PNRs and magnetic correlation, and establishes the magnetic and dielectric phase diagrams of the relaxor magnet.

1. Quantum-Phase-Transition-Induced Multiferroics and Higgs Mode in Integer Spin Systems in Noncentrosymmetric Lattice with Strong Single-Ion Anisotropy: M. Matsumoto, M. Soda and T. Masuda, J. Phys. Soc. Jpn. **82** (2013) 093703.

2. ^{63,65}Cu Nuclear Resonance Study of the Coupled Spin Dimers and Chains Compound $Cu_2Fe_2Ge_4O_{13}$: J. Kikuchi, S. Nagura, K. Murakami, T. Masuda and G. J. Redhammer, J. Phys. Soc. Jpn. **82** (2013) 034710(1-10).

3. 三軸分光器入門：益田 隆嗣 , 波紋 **23** (2013) 223-229.

4. Spin-Nematic Interaction in the Multiferroic Compound $Ba_2CoGe_2O_7$: M. Soda, M. Matsumoto, M. Mansson, S. Ohira-Kawamura, K. Nakajima, R. Shiina and T. Masuda, Phys. Rev. Lett. **112** (2014) 127205.

5. 1 次元フラストレート強磁性鎖のスピン密度波と Bond Nematic 相関： 萩原 雅人 , 益田 隆嗣 , 波紋 **23** (2013) 14-18.

International MegaGauss Science Laboratory

Takeyama group

The electro-magnetic flux compression techniques have been established to generate magnetic fields over 700 T by employing a new type of primary coil (a copper lined iron coil). In such a high magnetic field, a measurement of the magnetic field should be reconsidered. In pulse magnet operation, the magnetic field has been determined by a pick-up coil, wound around a thin rod, converted from the detected induced voltage from $d\varphi/dt$ (φ, a magnetic flux), followed by a certain process of calibration. We have found recently that the pick-up coil is not a reliable method anymore in such an extremely high magnetic fields. A Faraday rotation angle of quartz and the other glasses was measured up to a peak field and is calibrated with the signals from the pick-up coil. The present study revealed that the conventional pick-up coil method underestimated the values of the peak fields at least 10 %, so that 730 T ever reported could possibly reach 800 T.

1. Band-edge exciton states in a single-walled carbon nanotube revealed by magneto-optical spectroscopy in ultrahigh magnetic fields: W. Zhou, T. Sasaki, D. Nakamura, H. Liu, H. Kataura and S. Takeyama, Phys. Rev. B **87** (2013) 241406(1-4).

2. [*]Cyclotron resonance in ferromagnetic InMnAs and InMnSb: G. Khodaparast, Y. H. Matsuda, D. Saha, G. Sanders, C. Stanton, H. Saito, S. Takeyama, T. Merritt, C. Feeser, B. Wessels, X. Liu and J. Furdyna, Phys. Rev. B **88** (2013) 235204(11pages).

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* Joint research among groups within ISSP.

3. Magnetic superfluid state in the frustrated spinel oxide $CdCr_2O_4$ revealed by ultrahigh magnetic fields: A. Miyata, S. Takeyama and H. Ueda, Phys. Rev. B **87** (2013) 214424(1-6).

4. Magneto-photoluminescence of charged excitons from $Mg_xZn_{1-x}O/ZnO$ heterojunctions: T. Makino, Y. Segawa, A. Tsukazaki, H. Saito, S. Takeyama, S. Akasaka, K. Nakahara and M. Kawasaki, Phys. Rev. B **87** (2013) 085312(1-7).

5. [*]Precise measurement of a magnetic field generated by the electromagnetic flux compression technique: D. Nakamura, H. Sawabe, Y. H. Matsuda and S. Takeyama, Rev. Sci. Instrum. **84** (2013) 044702 (10 pages).

6. [*]Magnetization of $SrCu_2(BO_3)_2$ in Ultrahigh Magnetic Fields up to 118 T: Y. H. Matsuda, N. Abe, S. Takeyama, H. Kageyama, P. Corboz, A. Honecker, S. R. Manmana, G. R. Foltin, K. P. Schmidt and F. Mila, Phys. Rev. Lett. **111** (2013) 137204 (5 pages).

7. [*]Magnetization Studies of Field-Induced Transitions by Using a Single-Turn Coil Technique: N. Abe, Y. H. Matsuda, S. Takeyama, K. Sato, H. Kageyama and Y. Nishiwaki, J. Low Temp. Phys. **170** (2013) 452-456.

8. [†*]Magneto-Absorption in the Phase of Solid Oxygen at Megagauss Magnetic Fields: T. Nomura, Y. H. Matsuda, J. L. Her, S. Takeyama, A. Matsuo, K. Kindo and T. C. Kobayashi, J. Low Temp. Phys. **170** (2013) 372-376.

9. [*]Precision of an Ultra-high Magnetic Field Generated by the Electro-magnetic Flux Compression: D. Nakamura, Y. H. Matsuda and S. Takeyama, J. Low Temp. Phys. **170** (2013) 457-462.

10. Exciton-phonon bound complex in single-walled carbon nanotubes revealed by high-field magneto-optical spectroscopy: W. Zhou, T. Sasaki, D. Nakamura, H. Saito, H. Liu, H. Kataura and S. Takeyama, Appl. Phys. Lett. **103** (2013) 233101.

11. Survey of exciton-phonon sidebands by magneto-optical spectroscopy using highly specified (6,5) single-walled carbon nanotubes: W. Zhou, T. Sasaki, D. Nakamura, H. Saito, H. Liu, H. Kataura and S. Takeyama, Appl. Phys. Lett. **103** (2013) 021117(1-4).

12. Infrared cyclotron resonances of Dirac electrons in SiC epitaxial graphene in ultra-high magnetic fields: H. Saito, D. Nakamura, S. Takeyama and H. Hibino, AIP Conf. Proc. **1566** (2013) 145.

13. [*]Magneto-optical study of Dirac fermion in quartz CVD-grown graphene above 100 T: D. Nakamura, H. Saito, W. Zhou, Y. H. Matsuda, S. Takeyama, K. Yagi, K. Hayashi and S. Sato, AIP Conf. Proc. **1566** (2013) 169-170.

14. Magneto-optical survey of 1st and 2nd sub-bands in chirality specific (6, 5) single-walled carbon nanotube up to 190 T: T. Sasaki, W. Zhou, D. Nakamura, H. Liu, H. Kataura and S. Takeyama, AIP Conf. Proc. **1566** (2013) 171.

15. Canted 2:1:1 Magnetic Supersolid Phase in a Frustrated Magnet $MgCr_2O_4$ as a Small Limit of the Biquadratic Spin Interaction: A. Miyata, H. Ueda and S. Takeyama, J. Phys. Soc. Jpn. **83** (2014) 063702(1-4).

16. Note: Experimental evidence of three-dimensional dynamics of an electromagnetically imploded liner: D. Nakamura, H. Sawabe and S. Takeyama, Rev. Sci. Instrum. **85** (2014) 036102.

Kindo group

A new user coil has been installed. The coil can generate a short pulsed field with duration of 4 ms. 75 T field can be used every half hour. A new long-pulse magnet has been installed. The magnet can generate a long pulsed field with duration of about 1 sec. The maximum field of 36 T can be generated. Heat capacity measurement under the long pulsed field can be carried out.

1. [†]Antiferromagnetic ordering in Sr_2CrO_4: M. Rani, H. Sakurai, S. Okubo, K. Takamoto, R. Nakata, T. Sakurai, H. Ohta, A. Matsuo, Y. Kohama, K. Kindo and J. Ahmad, J. Phys.: Condens. Matter **25** (2013) 226001(1-5).

2. Collapse of Magnetic Order of the Quasi One-Dimensional Ising-Like Antiferromagnet $BaCo_2V_2O_8$ in Transverse Fields: S. Kimura, K. Okunishi, M. Hagiwara, K. Kindo, Z. He, T. Taniyama, M. Itoh, K. Koyama and K. Watanabe, J. Phys. Soc. Jpn. **82** (2013) 033706(1-4).

3. [†]Crystal Structure and Magnetic Properties of the Verdazyl Biradical *m*-Ph-V_2 Forming a Ferromagnetic Alternating Double Chain: K. Iwase, H. Yamaguchi, T. Ono, T. Shimokawa, H. Nakano, A. Matsuo, K. Kindo, H. Nojiri and Y. Hosokoshi, J. Phys. Soc. Jpn. **82** (2013) 074719(1-6).

4. [†*]High-Field Phase Diagram of $SmRu_4P_{12}$ Determined by Ultrasonic Measurements in Pulsed Magnetic Field up to 55 T: M. Yoshizawa, H. Mitamura, F. Shichinomiya, S. Fukuda, Y. Nakanishi, H. Sugawara, T. Sakakibara and K. Kindo, J. Phys. Soc. Jpn. **82** (2013) 033602(1-5).

[†] Joint research with outside partners.

5. †Marked Change in the Ground State of $CeRu_2Al_{10}$ Induced by Small Amount of Rh Substitution: A. Kondo, K. Kindo, K. Kunimori, H. Nohara, H. Tanida, M. Sera, R. Kobayashi, T. Nishioka and M. Matsumura, J. Phys. Soc. Jpn. **82** (2013) 054709(1-5).

6. Metamagnetic Behavior and Effect of Pressure on the Electronic State in Heavy-Fermion Compound $YbRh_2Zn_{20}$: F. Honda, T. Takeuchi, S. Yasui, Y. Taga, S. Yoshiuchi, Y. Hirose, Y. Tomooka, K. Sugiyama, M. Hagiwara, K. Kindo, R. Settai and Y. Onuki, J. Phys. Soc. Jpn. **82** (2013) 084705(1-10).

7. †Spin-Dependent Molecular Orientation of O_2–O_2 Dimer Formed in the Nanoporous Coordination Polymer: A. Hori, T. C. Kobayashi, Y. Kubota, A. Matsuo, K. Kindo, J. Kim, K. Kato, M. Takata, H. Sakamoto, R. Matsuda and S. Kitagawa, J. Phys. Soc. Jpn. **82** (2013) 084703(6).

8. *Temperature and Magnetic Field Dependent Yb Valence in $YbRh_2Si_2$ Observed by X-ray Absorption Spectroscopy: H. Nakai, T. Ebihara, S. Tsutsui, M. Mizumaki, N. Kawamura, S. Michimura, T. Inami, T. Nakamura, A. Kondo, K. Kindo and Y. H. Matsuda, J. Phys. Soc. Jpn. **82** (2013) 124712 (5pages).

9. †Crystal structure and magnetic properties of honeycomb-like lattice antiferromagnet p-BIP-V_2: H. Yamaguchi, S. Nagata, M. Tada, K. Iwase, T. Ono, S. Nishihara, Y. Hosokoshi, T. Shimokawa, H. Nakano, H. Nojiri, A. Matsuo, K. Kindo and T. Kawakami, Phys. Rev. B **87** (2013) 125120(1-8).

10. †High magnetic field study of the Tm_2Fe_{17} and $Tm_2Fe_{17}D_{3.2}$ compounds: O. Isnard, A. V. Andreev, M. D. Kuz'min, Y. Skourski, D. I. Gorbunov, J. Wosnitza, N. V. Kudrevatykh, A. Iwasa, A. Kondo, A. Matsuo and K. Kindo, Phys. Rev. B **88** (2013) 174406(1-10).

11. †*Quasi-one-dimensional S=1/2 Heisenberg antiferromagnetic chain consisting of the organic radical p-Br-V: K. Iwase, H. Yamaguchi, T. Ono, Y. Hosokoshi, T. Shimokawa, Y. Kono, S. Kittaka, T. Sakakibara, A. Matsuo and K. Kindo, Phys. Rev. B **88** (2013) 184431(1-5).

12. †*Various regimes of quantum behavior in an S=1/2 Heisenberg antiferromagnetic chain with fourfold periodicity: H. Yamaguchi, T. Okubo, K. Iwase, T. Ono, Y. Kono, S. Kittaka, T. Sakakibara, A. Matsuo, K. Kindo and Y. Hosokoshi, Phys. Rev. B **88** (2013) 174410(1-5).

13. †Magnetization Process and Collective Excitations in the S=1/2 Triangular-Lattice Heisenberg Antiferromagnet $Ba_3CoSb_2O_9$: T. Susuki, N. Kurita, T. Tanaka, H. Nojiri, A. Matsuo, K. Kindo and H. Tanaka, Phys. Rev. Lett. **110** (2013) 267201(5).

14. †*High Field Magnetization of $TbPd_2Ge_2$ Single Crystal: T. Shigeoka, T. Hasegawa, T. Fujiwara, A. Kondo, K. Kindo and Y. Uwatoko, J. Low Temp. Phys. **170** (2013) 248-254.

15. †*Magneto-Absorption in the α Phase of Solid Oxygen at Megagauss Magnetic Fields: T. Nomura, Y. H. Matsuda, J. L. Her, S. Takeyama, A. Matsuo, K. Kindo and T. C. Kobayashi, J. Low Temp. Phys. **170** (2013) 372-376.

16. *Observation of Field-induced Anomaly in High-field Magnetization on a Complex Spin-Driven Multiferroic Compound, $LiCu_{2-z}Zn_zO_2$: J. L. Her, H. C. Hsu, Y. H. Matsuda, K. Kindo and F. C. Chou, J. Low Temp. Phys. **170** (2013) 285-290.

17. †Present Status and Future Plan at High Magnetic Field Laboratory in Osaka University: M. Hagiwara, T. Kida, K. Taniguchi and K. Kindo, J. Low Temp. Phys. **170** (2013) 531-540.

18. †*Magnetic field hysteresis under various sweeping rates for Ni-Co-Mn-In metamagnetic shape memory alloys: X. Xu, T. Kihara, M. Tokunaga, A. Matsuo, W. Ito, R. Y. Umetsu, K. Kindo and R. Kainuma, Appl. Phys. Lett. **103** (2013) 122406(1-4).

19. †Itinerant electron magnetism of η-carbides Co_6M_6C and Ni_6M_6C (M=Mo and W): T. Waki, D. Furusawa, Y. Tabata, C. Michioka, K. Yoshimura, A. Kondo, K. Kindo and H. Nakamura, J. Alloys Compd. **554** (2013) 21-24.

20. †*Optical imaging and magnetocaloric effect measurements in pulsed high magnetic fields and their application to Ni–Co–Mn–In Heusler alloy: T. Kihara, I. Katakura, M. Tokunaga, A. Matsuo, K. Kawaguchi, A. Kondo, K. Kindo, W. Ito, X. Xu and R. Kainuma, J. Alloys Compd. **577** (2013) S722-S725.

21. †Magnetoresistance and Transformation Hysteresis in the $Ni_{50}Mn_{34.4}In_{15.6}$ Metamagnetic Shape Memory Alloy: R. Y. Umetsu, K. Endo, A. Kondo, K. Kindo, W. Ito, X. Xu, T. Kanomata and R. Kainuma, Mater. Trans. **54** (2013) 291.

22. †Magnetic properties of the frustrated magnet $Cu_5(PO_4)_3(OH)_4$ on a peculiar spin network composed of pentagons and triangles: H. Kikuchi, Y. Nguyen Thi Tinh, Y. Fujii, A. Matsuo and K. Kindo, J. Kor. Phys. Soc. **62** (2013) 2037-2040.

---

* Joint research among groups within ISSP.

23. [*]Heat-pulse measurements of specific heat in 36 ms pulsed magnetic fields: Y. Kohama, Y. Hashimoto, S. Katsumoto, M. Tokunaga and K. Kindo, Meas. Sci. Technol. **24** (2013) 115005(1-9).

24. [†]Spin Frustration and Field-Induced Transitions of Modified Pyrochlore Fluorides ACr_2F_6 (A = Rb and Cs): H. Ueda, A. Matsuo, K. Kindo and K. Yoshimura, J. Phys. Soc. Jpn. **83** (2014) 014701(1-6)

25. [†]Unconventional spin freezing in the highly two-dimensional spin-l/2 kagome antiferromagnet $Cd_2Cu_3(OH)6(SO_4)24H_2O$: Evidence of partial order and coexisting spin singlet state on a distorted kagome lattice: M. Fujihala, X.-G. Zheng, H. Morodomi, T. Kawae, A. Matsuo, K. Kindo and I. Watanabe, Phys. Rev. B **89** (2014) 100401(1-5).

Tokunaga group

By measuring the resistance of thin-film thermometers deposited on the sample surface, we succeeded in rapid temperature monitoring of the sample with the response time shorter than 0.1 ms. With using this technique, we developed a measurement system of magneto-caloric effects in pulsed high magnetic fields up to 55 T. This technique provides us of novel thermodynamic information of various kind of phase transitions induced in high magnetic fields and also direct information of the entropy in frustrated magnets.

1. Giant Magnetoresistance Effect in the Metal–Insulator Transition of Pyrochlore Oxide $Nd_2Ir_2O_7$: K. Matsuhira, M. Tokunaga, M. Wakeshima, Y. Hinatsu and S. Takagi, J. Phys. Soc. Jpn. **82** (2013) 023706(1-4).

2. High-Field Magnetization of Quasi-One-Dimensional Ising-Like Antiferromagnet $TlCoCl_3$: Y. Nishiwaki, M. Tokunaga, N. Todoroki and T. Kato, J. Phys. Soc. Jpn. **82** (2013) 104717(1-5).

3. Metamagnetic Transition and Its Related Magnetocapacitance Effect in Phthalocyanine-Molecular Conductor Exhibiting Giant Magnetoresistance: N. Hanasaki, T. Tateishi, H. Tajima, M. Kimata, M. Tokunaga, M. Matsuda, A. Kanda, H. Murakawa, T. Naito and T. Inabe, J. Phys. Soc. Jpn. **82** (2013) 094713(1-5).

4. Thermal Transport and Magnetotransport Properties of $CuCr_{1-x}Mg_xO_2$ with a Spin-3/2 Antiferromagnetic Triangular Lattice: T. Okuda, S. Oozono, T. Kihara and M. Tokunaga, J. Phys. Soc. Jpn. **82** (2013) 014706(1-7).

5. Magnetic control of electric polarization in the noncentrosymmetric compound $(Cu,Ni)B_2O_4$: N. D. Khanh, N. Abe, K. Kubo, M. Akaki, M. Tokunaga, T. Sasaki and T. Arima, Phys. Rev. B **87** (2013) 184416(1-5).

6. Shubnikov–de Haas oscillations in the bulk Rashba semiconductor BiTeI: C. Bell, M. S. Bahramy, H. Murakawa, J. G. Checkelsky, R. Arita, Y. Kaneko, Y. Onose, M. Tokunaga, Y. Kohama, N. Nagaosa, Y. Tokura and H. Y. Hwang, Phys. Rev. B **87** (2013) 081109(R)(1-5).

7. [†*]Adiabatic measurements of magneto-caloric effects in pulsed high magnetic fields up to 55 T: T. Kihara, Y. Kohama, Y. Hashimoto, S. Katsumoto and M. Tokunaga, Rev. Sci. Instrum. **84** (2013) 074901(1-7).

8. Field-Induced Magnetostructural Transitions in Antiferromagnetic $Fe_{1+y}Te_{1-x}S_x$: M. Tokunaga, T. Kihara, Y. Mizuguchi and Y. Takano, J. Low Temp. Phys. **170** (2013) 340-345.

9. High Magnetic Field Dependence of Magnetodielectric Properties in $Sr_2CoSi_2O_7$ Crystal: M. Akaki, T. Tadokoro, T. Kihara, M. Tokunaga and H. Kuwahara, J. Low Temp. Phys. **170** (2013) 291-295.

10. [†*]Magnetic field hysteresis under various sweeping rates for Ni-Co-Mn-In metamagnetic shape memory alloys: X. Xu, T. Kihara, M. Tokunaga, A. Matsuo, W. Ito, R. Y. Umetsu, K. Kindo and R. Kainuma, Appl. Phys. Lett. **103** (2013) 122406(1-4).

11. Detection of Berry's Phase in a Bulk Rashba Semiconductor: H. Murakawa, M. S. Bahramy, M. Tokunaga, Y. Kohama, C. Bell, Y. Kaneko, N. Nagaosa, H. Y. Hwang and Y. Tokura, Science **342** (2013) 1490-1493.

12. Spin Frustration from *cis* -Edge or -Corner Sharing Metal-Centered Octahedra: R. Gautier, K. Oka, T. Kihara, N. Kumar, A. Sundaresan, M. Tokunaga, M. Azuma and K. R. Poeppelmeier, J. Am. Chem. Soc. **135** (2013) 19268-19274.

13. [†*]Optical imaging and magnetocaloric effect measurements in pulsed high magnetic fields and their application to Ni–Co–Mn–In Heusler alloy: T. Kihara, I. Katakura, M. Tokunaga, A. Matsuo, K. Kawaguchi, A. Kondo, K. Kindo, W. Ito, X. Xu and R. Kainuma, J. Alloys Compd. **577** (2013) S722-S725.

14. Optical Microscopic Study on NiCoMnAl Metamagnetic Shape Memory Alloy by In Situ Observation under a Pulsed High Magnetic Field: X. Xu, I. Katakura, T. Kihara, M. Tokunaga, W. Ito, R. Y. Umetsu and R. Kainuma, Mater. Trans. **54** (2013) 357-362.

[†] Joint research with outside partners.

15. Anisotropic magnetic properties in Åkermanite $Sr_2MSi_2O_7$ (M=Co, Mn) crystals: M. Akaki, T. Tadokoro, H. Kuwahara, T. Kihara and M. Tokunaga, J. Kor. Phys. Soc. **62** (2013) 1812-1814.

16. Magnetotransport property of the hole-doped delafossite $CuCr_{0.97}Mg_{0.03}O_2$ with a Spin-3/2 antiferromagnetic triangular sublattice: T. Okuda, S. Oozono, T. Kihara and M. Tokunaga, J. Kor. Phys. Soc. **62** (2013) 2168-2172.

17. [*]Heat-pulse measurements of specific heat in 36 ms pulsed magnetic fields: Y. Kohama, Y. Hashimoto, S. Katsumoto, M. Tokunaga and K. Kindo, Meas. Sci. Technol. **24** (2013) 115005(1-9).

Y. Matsuda group

The magnetization process of $SrCu_2(BO_3)_2$ shows exotic multi-plateau structure, indicating the crystallization of the excited triplet dimers with the several factional fillings in the sea of the singlet dimers. We have succeeded in observing the magnetization curve of $SrCu_2(BO_3)_2$ in ultrahigh magnetic fields of up to 118 Tesla. The long predicted 1/2 plateau has been clearly observed at the field range from 84 to 108 Tesla for the first time. A destructive way of magnetic field generation, single-turn coil method (STC), was used for the experiment. In addition to the magnetization measurement, the cyclotron resonance in ferromagnetic semiconductors and magneto-absorption spectroscopy in solid oxygen have been performed at very high magnetic fields over 100 Tesla. The synchrotron x-ray spectroscopy on Yb-based heavy fermion compounds $YbRh_2Si_2$ and $YbAlB_4$ revealed that the valence instability was affected by a strong magnetic field, suggesting the importance of the charge degree of freedom for understanding their exotic properties at very low temperatures.

1. [*]Temperature and Magnetic Field Dependent Yb Valence in $YbRh_2Si_2$ Observed by X-ray Absorption Spectroscopy: H. Nakai, T. Ebihara, S. Tsutsui, M. Mizumaki, N. Kawamura, S. Michimura, T. Inami, T. Nakamura, A. Kondo, K. Kindo and Y. H. Matsuda, J. Phys. Soc. Jpn. **82** (2013) 124712 (5pages).

2. X-ray Diffraction and Absorption Spectroscopy in Pulsed High Magnetic Fields: Y. H. Matsuda and T. Inami, J. Phys. Soc. Jpn. **82** (2013) 021009 (17 pages).

3. [*]Cyclotron resonance in ferromagnetic InMnAs and InMnSb: G. Khodaparast, Y. H. Matsuda, D. Saha, G. Sanders, C. Stanton, H. Saito, S. Takeyama, T. Merritt, C. Feeser, B. Wessels, X. Liu and J. Furdyna, Phys. Rev. B **88** (2013) 235204(11pages).

4. [*]Precise measurement of a magnetic field generated by the electromagnetic flux compression technique: D. Nakamura, H. Sawabe, Y. H. Matsuda and S. Takeyama, Rev. Sci. Instrum. **84** (2013) 044702 (10 pages).

5. [*]Magnetization of $SrCu_2(BO_3)_2$ in Ultrahigh Magnetic Fields up to 118 T: Y. H. Matsuda, N. Abe, S. Takeyama, H. Kageyama, P. Corboz, A. Honecker, S. R. Manmana, G. R. Foltin, K. P. Schmidt and F. Mila, Phys. Rev. Lett. **111** (2013) 137204 (5 pages).

6. [*]Magnetization Studies of Field-Induced Transitions by Using a Single-Turn Coil Technique: N. Abe, Y. H. Matsuda, S. Takeyama, K. Sato, H. Kageyama and Y. Nishiwaki, J. Low Temp. Phys. **170** (2013) 452-456.

7. [†*]Magneto-Absorption in the Phase of Solid Oxygen at Megagauss Magnetic Fields: T. Nomura, Y. H. Matsuda, J. L. Her, S. Takeyama, A. Matsuo, K. Kindo and T. C. Kobayashi, J. Low Temp. Phys. **170** (2013) 372-376.

8. [*]Observation of Field-induced Anomaly in High-field Magnetization on a Complex Spin-Driven Multiferroic Compound, $LiCu_{2-z}Zn_zO_2$: J. L. Her, H. C. Hsu, Y. H. Matsuda, K. Kindo and F. C. Chou, J. Low Temp. Phys. **170** (2013) 285-290.

9. [*]Precision of an Ultra-high Magnetic Field Generated by the Electro-magnetic Flux Compression: D. Nakamura, Y. H. Matsuda and S. Takeyama, J. Low Temp. Phys. **170** (2013) 457-462.

10. Structural and electrical characteristics of high-κ $ErTi_xO_y$ gate dielectrics on InGaZnO thin-film transistors: F.-H. Chen, J.-L. Her, Y.-H. Shao, W.-C. Li, Y. H. Matsuda and T.-M. Pan, Thin Solid Films **539** (2013) 251-255.

11. Effect of surface roughness on electrical characteristics in amorphous InGaZnO thin-film transistors with high-κ Sm_2O_3 dielectrics: F.-H. Chen, M.-N. Hung, J.-F. Yang, S.-Y. Kuo, J.-L. Her, Y. H. Matsuda and T.-M. Pan, Journal of Physics and Chemistry of Solids **74** (2013) 570-574.

12. [*]Magneto-optical study of Dirac fermion in quartz CVD-grown graphene above 100 T: D. Nakamura, H. Saito, W. Zhou, Y. H. Matsuda, S. Takeyama, K. Yagi, K. Hayashi and S. Sato, AIP Conf. Proc. **1566** (2013) 169-170.

13. [*]Chemical effects of high-resolution Yb $L\gamma_4$ emission spectra: a possible probe for chemical analysis: H. Hayashi, N. Kanai, N. Kawamura, Y. H. Matsuda, K. Kuga, S. Nakatsuji, T. Yamashita and S. Ohara, X-Ray Spectrom. **42** (2013) 450-455.

---

* Joint research among groups within ISSP.

14. *Synchrotron X-ray spectroscopy study on the valence state in α- and β-$YbAlB_4$ at low temperatures and high magnetic fields: Y. H. Matsuda, T. Nakamura, K. Kuga, S. Nakatsuji, S. Michimura, T. Inami, N. Kawamura and M. Mizumaki, J. Kor. Phys. Soc. **62** (2013) 1778-1781.

15. Structural and electrical characteristics of high-κ Er_2O_3 and Er_2TiO_5 gate dielectrics for a-IGZO thin-film transistors: F.-H. Chen, J.-L. Her, Y.-H. Shao, Y. H. Matsuda and T.-M. Pan, Nanoscale Res Lett **8** (2013) 18 (5 pages).

16. *Magnetization of Yb-based mixed-valent compounds at megagauss fields: T. Terashima, Y. H. Matsuda, K. Kuga, Y. Matsumoto and S. Nakatsuji, J. Phys. Soc. Jpn. (2014), in print.

Center of Computational Materials Science

Akai group

We have developed methodologies that enable us to calculate electronic structure of wide range of systems such as strongly correlated systems and systems in non-equlibrium states. One of them is a scheme of first-principles calculation of the non-equilibrium Green's function of tunnelling junctions in the framework of the Korringa-Kohn-Rostoker (KKR) Green's function method is developed. Another is the optimized effective potential (OEP) method applied to static RPA scheme. The latter includes an elaboration that dissolves a well-known difficulty arising from the indefiniteness inherent in the theory of OEP. One of main topics we are now working on is the theory of permanent magnet. This year we have developed the theory of magnetic anisotropy of Sm-Fe-N magnet, in particular discussing the role of N that experimentally is is known to be important to realize the uni-axial magnetic anisotropy of this system.

1. Basic and applications of Moessbauer spectrometry and the electronics structure of matters: H. Akai, ISOTOPES **63** (2014) 163-174.

2. 鉄の事典：赤井 久純 , (朝倉書店 , 東京 , 2014) in print.

Todo group

We study novel phases and critical phenomena in strongly correlated many-body systems, such as quantum magnets and Bose-Hubbard model, by using the state-of-the-art computational physics techniques like the quantum Monte Carlo method. We also develop new computational algorithms for quantum many-body systems, such as the tensor-network method, study the parallelization technique for supercomputers, and develop open-source software for next-generation parallel simulations: (1) Analysis of quantum phases and quantum phase transitions by local Z2 Berry phase (2) Critical phenomena of long-range interacting spin model (3) Quantum phase transition of SU(N) J-Q model (4) Irreversible Markov chain Monte Carlo (5) Simulation method for systems with strong spatial anisotropy (6) Parallelization of worm algorithm quantum Monte Carlo method (7) Parallel exact diagonalization package “Rokko".

1. Long-Range Order of the Three-Sublattice Structure in the S =1 Heisenberg Antiferromagnet on a Spatially Anisotropic Triangular Lattice: H. Nakano, S. Todo and T. Sakai, J. Phys. Soc. Jpn. **82** (2013) 043715.

2. *Possibility of deconfined criticality in SU(N) Heisenberg models at small N: K. Harada, T. Suzuki, T. Okubo, H. Matsuo, J. Lou, H. Watanabe, S. Todo and N. Kawashima, Phys. Rev. B **88** (2013) 220408(1-4).

3. Monte Carlo simulation with aspect-ratio optimization: Anomalous anisotropic scaling in dimerized antiferromagnets: S. Yasuda and S. Todo, Phys. Rev. E **88** (2013) 061301.

4. Path-integral Monte Carlo method for the local Z_2 Berry phase: Y. Motoyama and S. Todo, Phys. Rev. E **87** (2013) 021301(1-5).

5. Geometric allocation approaches in Markov chain Monte Carlo: S. Todo and H. Suwa, J. Phys.: Conf. Ser. **473** (2013) 012013.

6. 詳細つりあいを満たさないマルコフ連鎖モンテカルロ法とその一般化：諏訪 秀麿 , 藤堂 眞治 , 数理解析研究所 講究録 **1848** (2013) 93.

7. Numerical Analysis of Quantum Phase Transitions with Dynamic Control of Anisotropy: S. Yasuda and S. Todo, JPS Conf. Proc. **1** (2014) 012127.

8. Path-Integral Monte Carlo for the Gauge-Fixed Berry Connection and the Local Z_2 Berry Phase: Y. Motoyama and S. Todo, JPS Conf. Proc. **1** (2014) 012130.

† Joint research with outside partners.

9. Loop Algorithm: S. Todo, in: *Strongly Correlated Systems: Numerical Methods (Springer Series in Solid-State Sciences)*, Ch 6, edited by A. Avella and F. Mancini, (Springer-Verlag, Berlin, 2013), 153-184.

Laser and Synchrotron Research Center

Suemoto group

To study ultrafast spin dynamics in canted ferromagnets, terahertz pump-Faraday probe experiments were performed on orthoferrites and several new aspects were revealed as follows. (1) Extremely long coherence time and beating phenomena were found in spin precession modes. (2) Dynamics of magnetic anisotropy parameters modified by optical excitation was observed. (3) Resonance enhancement of the spin precession by using a metamaterial structure (split ring resonator) was demonstrated. As for the photoinduced phase transition, femtosecond dynamics in a novel nanocrystalline titanium oxide was studied and ultrafast phase change was confirmed, which guarantees usefulness of this material for optical storage. Newtons's ring in soft x-ray region (at 13.9 nm) was firstly observed during the laser ablation process, suggesting an extremely thin and flat expansion front.

1. †Dynamics of pulsed laser ablation in high-density carbon dioxide including supercritical fluid state: K. Urabe, T. Kato, S. Stauss, S. Himeno, S. Kato, H. Muneoka, M. Baba, T. Suemoto and K. Terashima, J. Appl. Phys. **114** (2013) 143303.

2. *Access to hole dynamics in graphite by femtosecond luminescence and photoemission spectroscopy: T. Suemoto, S. Sakaki, M. Nakajima, Y. Ishida and S. Shin, Phys. Rev. B **87** (2013) 224302(1-5).

3. *Mechanism of Enhanced Optical Second-Harmonic Generation in the Conducting Pyrochlore-Type $Pb_2Ir_2O_{7-x}$ Oxide Compound: Y. Hirata, M. Nakajima, Y. Nomura, H. Tajima, Y. Matsushita, K. Asoh, Y. Kiuchi, A. G. Eguiluz, R. Arita, T. Suemoto and K. Ohgushi, Phys. Rev. Lett. **110** (2013) 187402(1-5).

4. Terahertz Time-Domain Observation of Spin Reorientation in Orthoferrite $ErFeO_3$ through Magnetic Free Induction Decay: K. Yamaguchi, T. Kurihara, Y. Minami, M. Nakajima and T. Suemoto, Phys. Rev. Lett. **110** (2013) 137204 1-5.

5. Dielectric probe for scattering-type terahertz scanning near-field optical microscopy: T. Kurihara, K. Yamaguchi, H. Watanabe, M. Nakajima and T. Suemoto, Appl. Phys. Lett. **103** (2013) 151105.

6. High-power THz wave generation in plasma induced by polarization adjusted two-color laser pulses: Y. Minami, T. Kurihara, K. Yamaguchi, M. Nakajima and T. Suemoto, Appl. Phys. Lett. **102** (2013) 041105(1-4).

7. Longitudinal THz wave generation from an air plasma filament induced by a femtosecond lase: Y. Minami, T. Kurihara, K. Yamaguchi, M. Nakajima and T. Suemoto, Appl. Phys. Lett. **102** (2013) 151106(1-3).

8. †Pulsed laser ablation plasmas generated in CO_2 under high-pressure conditions up to supercritical fluid: T. Kato, S. Stauss, S. Kato, K. Urabe, M. Baba, T. Suemoto and K. Terashima, Appl. Phys. Lett. **101** (2013) 224013(1-4).

9. †Probing of local structures of thermal and photoinduced phases in rubidium manganese hexacyanoferrate by resonant Raman spectroscopy: R. Fukaya, A. Asahara, S. Ishige, M. Nakajima, H. Tokoro, S.-I. Ohkoshi and T. Suemoto, J. Chem. Phys. **139** (2013) 084303(1-7).

10. †The synthesis of rhodium substituted ε-iron oxide exhibiting super high frequency natural resonance: A. Namai, M. Yoshikiyo, S. Umeda, T. Yoshida, T. Miyazaki, M. Nakajima, K. Yamaguchi, T. Suemoto and S. Ohkoshi, Journal of Materials Chemistry C **1** (2013) 5200-5206.

11. *Gain-switching dynamics in optically pumped single-mode InGaN vertical-cavity surface-emitting lasers: S. Chen, A. Asahara, T. Ito, J. Zhang, B. Zhang, T. Suemoto, M. Yoshita and H. Akiyama, Optics Express **22** (2014) 4196-4201.

12. *Spectral dynamics of picosecond gain-switched pulses from nitride-based vertical-cavity surface-emitting lasers: S. Chen, T. Ito, A. Asahara, M. Yoshita, W. Liu, J. Zhang, B. Zhang, T. Suemoto and H. Akiyama, Sci. Rep. **4** (2014) 4325.

Shin group

We studied high Tc Fe-pnictide superconductors using 7-eV laser. High resolution photoemission study with polarization dependence is very powerful for the study of the superconducting mechanism. Orbital fluctuation mechanism is also important in addition to the spin fluctuation mechanism.

1. Bulk-Sensitive Angle-Resolved PhotoemissionSpectroscopy on TTF-TCNQ: K. Koizumi, K. Ishizaka, T. Kiss, M. Okawa, R. Kato and S. Shin, J. Phys. Soc. Jpn. **82** (2013) 025004(1-2).

---

* Joint research among groups within ISSP.

2. [*]Access to hole dynamics in graphite by femtosecond luminescence and photoemission spectroscopy: T. Suemoto, S. Sakaki, M. Nakajima, Y. Ishida and S. Shin, Phys. Rev. B **87** (2013) 224302(1-5).

3. Quantifying covalency and metallicity in correlated compounds undergoing metal-insulator transitions: A. Chainani, A. Yamamoto, M. Matsunami, R. Eguchi, M. Taguchi, Y. Takata, S. Shin, Y. Nishino, M. Yabashi, K. Tamasaku and T. Ishikawa, Phys. Rev. B **87** (2013) 045108(1-10).

4. [†*]Anomalous Doping Variation of the Nodal Low-Energy Feature of Superconducting $(Bi,Pb)_2(Sr, La)_2CuO_{6+}$ Crystals Revealed by Laser-Based Angle-Resolved Photoemission Spectroscopy: T. Kondo, Y. Nakashima, W. Malaeb, Y. Ishida, Y. Hamaya, T. Takeuchi and S. Shin, Phys. Rev. Lett. **110** (2013) 217006(1-5).

5. [†*]Anomalous Dressing of Dirac Fermions in the Topological Surface State of Bi_2Se_3, Bi_2Te_3, and Cu-Doped Bi_2Se_3: T. Kondo, Y. Nakashima, Y. Ota, Y. Ishida, W. Malaeb, K. Okazaki, S. Shin, M. Kriener, S. Sasaki, K. Segawa and Y. Ando, Phys. Rev. Lett. **110** (2013) 217601(1-5).

6. Existence of Orbital Order and its Fluctuation in Superconducting $Ba(Fe_{1-x}Co_x)_2As_2$ Single Crystals Revealed by X-ray Absorption Spectroscopy: YK. Kim, WS. Jung, GR. Han, KY. Choi, CC. Chen, TP. Devereaux, A. Chainani, J. Miyawaki, Y. Takata, Y. Tanaka, M. Oura, S. Shin, A. P. Singh, H. G Lee, JY. Kim and C. Kim, Phys. Rev. Lett. **111** (2013) 217001(1-5).

7. [†*]Selective Probing of the OH or OD Stretch Vibration in Liquid Water Using Resonant Inelastic Soft-X-Ray Scattering: Y. Harada, T. Tokushima, Y. Horikawa, O. Takahashi, H. Niwa, M. Kobayashi, M. Oshima, Y. Senba, H. Ohashi, KT. Wikfeldt, A. Nilsson, LGM. Pettersson and S. Shin, Phys. Rev. Lett. **111** (2013) 193001(1-5).

8. Strongly Spin-Orbit Coupled Two-Dimensional Electron Gas Emerging near the Surface of Polar Semiconductors: M. Sakano, M. S. Bahramy, A. Katayama, T. Shimojima, H. Murakawa, Y. Kaneko, W. Malaeb, S. Shin, K. Ono, H. Kumigashira, R. Arita, N. Nagaosa, H. Y. Hwang, Y. Tokura and K. Ishizaka, Phys. Rev. Lett. **110** (2013) 107204(1-5).

9. [*]Resonant inelastic X-ray scattering of liquid water: A. Nilsson, T. Tokushima, Y. Horikawa, Y. Harada, M. P. Ljungberg, S. Shin and L. G. M. Pettersson, J. Electron Spectrosc. Relat. Phenom. **188** (2013) 84-100.

10. [†*]Surface electronic structure of the topological Kondo-insulator candidate correlated electron system SmB_6: M. Neupane, N. Alidoust, S. -Y. Xu, T. Kondo, Y. Ishida, D. J. Kim, C. Liu, I. Belopolski, Y. J. Jo, T. -R. Chang, H. -T. Jeng, T. Durakiewicz, L. Balicas, H. Lin, A. Bansil, S. Shin, Z. Fisk and M. Z. Hasan, Nat. Commun. **4** (2013) 2991(1-7).

11. [*] 液体水分子の内殻電子励起ダイナミクスと局所構造：原田 慈久，徳島 高，堀川 裕加，丹羽 秀治，木内 久雄，小林 正起，尾嶋 正治，辛 埴，しょうとつ **10** (2013) 14-20.

12. Evidence for excluding the possibility of d-wave superconducting-gap symmetry in Ba-doped KFe_2As_2: Y. Ota, K. Okazaki, Y. Kotani, T. Shimojima, W. Malaeb, S. Watanabe, C. -T. Chen, K. Kihou, C. H. Lee, A. Iyo, H. Eisaki, T. Saito, H. Fukazawa, Y. Kohori and S. Shin, Phys. Rev. B **89** (2014) 081103(1-5).

13. [†*]Observation of a giant Kerr rotation in a ferromagnetic transition metal by M-edge resonant magneto-optic Kerr effect: Sh. Yamamoto, M. Taguchi, M. Fujisawa, R. Hobara, S. Yamamoto, K. Yaji, T. Nakamura, K. Fujikawa, R. Yukawa, T. Togashi, M. Yabashi, M. Tsunoda, S. Shin and I. Matsuda, Phys. Rev. B **89** (2014) 064423(1-6).

14. [*]Pseudogap formation above the superconducting dome in iron pnictides: T. Shimojima, T. Sonobe, W. Malaeb, K. Shinada, A. Chainani, S. Shin, T. Yoshida, S. Ideta, A. Fujimori, H. Kumigashira, K. Ono, Y. Nakashima, H. Anzai, M. Arita, A. Ino, H. Namatame, M. Taniguchi, M. Nakajima, S. Uchida, Y. Tomioka, T. Ito, K. Kihou, C. H. Lee, A. Iyo, H. Eisaki, K. Ohgushi, S. Kasahara, T. Terashima, H. Ikeda, T. Shibauchi, Y. Matsuda and K. Ishizaka, Phys. Rev. B **89** (2014) 045101(1-10).

15. [†*]Ultrafast photoinduced transition of an insulating VO_2 thin film into a nonrutile metallic state: R. Yoshida, T. Yamamoto, Y. Ishida, H. Nagao, T. Otsuka, K. Saeki, Y. Muraoka, R. Eguchi, K. Ishizaka, T. Kiss, S. Watanabe, T. Kanai, J. Itatani and S. Shin, Phys. Rev. B **89** (2014) 205114(1-7).

16. [*]Robust Protection from Backscattering in the Topological Insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$: S. Kim, S. Yoshizawa, Y. Ishida, K. Eto, K. Segawa, Y. Ando, S. Shin and F. Komori, Phys. Rev. Lett. **112** (2014) 136802(1-5).

17. Selective Probing of the OH or OD Stretch Vibration in Liquid Water Using Resonant Inelastic Soft-X-Ray Scattering: Y. Harada, T. Tokushima, Y. Horikawa, O. Takahashi, H. Niwa, M. Kobayashi, M. Oshima, Y. Senba, H. Ohashi, KT. Wikfeldt, A. Nilsson, LGM. Pettersson and S. Shin, Phys. Rev. Lett. **111** (2014) 193001(1-5).

18. レーザー光電子分光による分子性導体の電子構造の観測：石坂 香子，小泉 健二，木須 孝幸，辛 埴，固体物理 **49** (2014) 153-162.

---

† Joint research with outside partners.

19. [*]Observing hot carrier distribution in an n-type epitaxial graphene on a SiC substrate: T. Someya, H. Fukidome, Y. Ishida, R. Yoshida, T. Iimori, R. Yukawa, K. Akikubo, Sh. Yamamoto, S. Yamamoto, T. Yamamoto, T. Kanai, K. Funakubo, M. Suemitsu, J. Itatani, F. Komori, S. Shin and I. Matsuda, Appl. Phys. Lett. **104** (2014) 161103(1-4).

20. [†*]Solvation dependence of valence electronic states of water diluted in organic solvents probed by soft X-ray spectroscopy: T. Tokushima, Y. Horikawa, O. Takahashi, H. Arai, K. Sadakane, Y. Harada, Y. Takata and S. Shin, Phys. Chem. Chem. Phys. **16** (2014) 10753.

21. Superconductivity in an electron band just above the Fermi level: possible route to BCS-BEC superconductivity: K. Okazaki1, Y. Ito, Y. Ota, Y. Kotani, T. Shimojima, T. Kiss, S. Watanabe, C. -T. Chen, S. Niitaka, T. Hanaguri, H. Takagi, A. Chainani and S. Shin, Sci. Rep. **4** (2014) 4109(1-6).

22. Development of a single-shot CCD-based data acquisition system for time-resolved X-ray photoelectron spectroscopy at an X-ray free-electron laser facility: M. Oura, T. Wagai, A. Chainani, J. Miyawaki, H. Sato, M. Matsunami, R. Eguchi, T. Kiss, T. Yamaguchi, Y. Nakatani, T. Togashi, T. Katayama, K. Ogawa, M. Yabashi, I. Y. Tanaka, Y. Kohmura, K. Tamasaku, S. Shin and T. Ishikawa, J.Syn.Rad. **21** (2014) 183-192.

23. The electronic structure of carbonate ion in aqueous solution studied by soft X-ray emission spectroscopy: Y. Horikawa A. Yoshida, O. Takahashi, H. Araia, T. Tokushima, T. Gejo and S. Shin, J.Mol.Liq **189** (2014) 9-12.

24. [†*]New soft X-ray beamline BL07LSU at SPring-8: S. Yamamoto, Y. Senba, T. Tanaka, H. Ohashi, T. Hirono, H. Kimura, M. Fujisawa, J. Miyawaki, A. Harasawa, T. Seike, S. Takahashi, N. Nariyama, T. Matsushita, M. Takeuchi, T. Ohata, Y. Furukawa, K. Takeshita, S. Goto, Y. Harada, S. Shin, H. Kitamura, A. Kakizaki, M. Oshima and I. Matsuda, J Synchrotron Rad **21** (2014) 352-365.

Takahashi group

We have been studying the structure and phase transition of surfaces and interfaces with diffraction techniques. Topological insulators attract much attention due to potential applications such as spintronics and quantum computing. The structure of a Bi(001)/Bi_2Te_3(001) heteroepitaxial film grown on Si(111) was studied with atomic layer resolution by using X-ray crystal truncation rod scattering in combination with a novel structure analysis method. We revealed the Bi thin film is heavily distorted due to the interaction with the substrate Bi_2Te_3, resulting in the topological phase transition of the Bi film. We could also get quantitative information on the structural inhomogeneity at the interface between both Bi/Bi_2Te_3 and Bi_2Te_3/Si(111).

1. Structure of a Bi/Bi_2Te_3 heteroepitaxial film studied by x-ray crystal truncation rod scattering: T. Shirasawa, J. Tsunoda, T. Hirahara and T. Takahashi, Phys. Rev. B **87** (2013) 075449(1-5).

2. A method for measuring the specular X-ray reflectivity with millisecond time resolution: W. Voegeli, T. Matsushita, E. Arakawa, T. Shirasawa, T. Takahashi and Y. F. Yano, J. Phys.: Conf. Ser. **425** (2013) 092003(1-4).

3. [†*]Scanning tunneling microscopic and spectroscopic studies on a crystalline silica monolayer epitaxially formed on hexagonal SiC(000-1) surfaces: H. Tochihara, T. Shirasawa, T. Suzuki, T. Miyamachi, T. Kajiwara, K. Yagyu, S. Yoshizawa, T. Takahashi, S. Tanaka and F. Komori, Appl. Phys. Lett. **104** (2014) 051601(1-4).

4. Determination of atomic positions in silicene on Ag(111) by low-energy electron diffraction: K. Kawahara, T. Shirasawa, R. Arafune, C. -L. Lin, T. Takahashi, M. Kawai and N. Takagi, Surf. Sci. **623** (2014) 25-28.

5. 「グラフェン／ SiC(000-1) 界面構造の研究」角田 潤一 , 新領域物質系 (2013).

6. Structure and transport properties 1 of Cu doped Bi_2Se_3 films: T. Shirasawa, M. Sugiki, T. Hirahara, M. Aitani, T. Shirai, S. Hasegawa and T. Takahashi, Phys. Rev. B (2014), accepted for publication.

Akiyama group

In 2013, we started experimental and theoretical study on energy conversion efficiencies and sub-cell internal luminescence yields of tandem solar cells on the basis of a detailed-balance relation. We applied this key relation to the study of intrinsic radiative lifetime of one-dimensional excitons, and fluorescent radiation thermometry at cryogenic temperatures. We also started collaboration on the photoluminescence emission of photoexcited undoped GaAs quantum wells induced by an intense single-cycle terahertz pulse. We intensively studied spectral dynamics in short-pulse generation via gain switching of semiconductor lasers, such as Fabry-Perot GaAs or InGaAs lasers, InGaN VCSELs, and InGaAsP DFB lasers. We developed and characterized double-core-slab-waveguide semiconductor lasers for end optical pumping. We studied the effect of site-directed mutant luciferase on quantitative green and orange/red emission intensities in firefly bioluminescence, and firefly oxyluciferin in enzymatic environment on the basis of stability monitoring. Intensive studies were made with TD-DFT theoretical calculations on electronic states for luciferin and oxyluciferin.

---

* Joint research among groups within ISSP.

1. Transient hot-carrier optical gain in a gain-switched semiconductor laser: T. Ito, S. Chen, M. Yoshita, T. Mochizuki, C. Kim, H. Akiyama, L. N. Pfeiffer and K. W. West, Appl. Phys. Lett. **103** (2013) 082117.

2. †Electroluminescence of GaNAs/GaAs MQWs p–i–n junctions grown by RF-MBE using modulated nitrogen radical beam source: N. Ohta, K. Arimoto, M. Shiraga, K. Ishii, M. Inada, S. Yanai, Y. Nakai, H. Akiyama, T. Mochizuki, T. Takahashi, N. Takahashi, H. Miyagawa, N. Tsurumachi, S. Nakanishi and S. Koshiba, J. Cryst. Growth **378** (2013) 150.

3. Fluorescent Radiation Thermometry at Cryogenic Temperatures Based on Detailed Balance Relation: T. Mochizuki, T. Ihara, M. Yoshita, S. Maruyama, H. Akiyama, L. N. Pfeiffer and K. W. West, Appl. Phys. Express **6** (2013) 056602 (1-3).

4. Dynamics of short-pulse generation via spectral filtering from intensely excited gain-switched 155-μm distributed-feedback laser diodes: S. Chen, M. Yoshita, A. Sato, T. Ito, H. Akiyama and H. Yokoyama, Opt. Express **21** (2013) 10597-10605.

5. Gain-switched pulses from InGaAs ridge-quantum-well lasers limited by intrinsic dynamical gain suppression: S. Chen, M. Yoshita, T. Ito, T. Mochizuki, H. Akiyama and H. Yokoyama, Opt. Express **21** (2013) 7570-7576.

6. Double-core-slab-waveguide semiconductor lasers for end optical pumping: T. Nakamura, T. Mochizuki, C. Kim, S. Chen, M. Yoshita and H. Akiyama, Applied Physics Express **6** (2013) 062702.

7. Impact of Site-Directed Mutant Luciferase on Quantitative Green and Orange/Red Emission Intensities in Firefly Bioluminescence: Y. Wang, H. Akiyama, K. Terakado and T. Nakatsu, Sci. Rep. **3** (2013) 2490.

8. Intrinsic radiative lifetime derived via absorption cross section of one-dimensional excitons: S. Chen, M. Yoshita, A. Ishikawa, T. Mochizuki, S. Maruyama, H. Akiyama, Y. Hayamizu, L. N. Pfeiffer and K. W. West, Sci. Rep. **3** (2013) 1941.

9. Theoretical Study of Firefly Luciferin p K_a Values-Relative Absorption Intensity in Aqueous Solutions: M. Hiyama, H. Akiyama, K. Yamada and N. Koga, Photochem Photobiol **89** (2013) 571.

10. Theoretical study for absorption spectra of oxyluciferin in aqueous solutions: M. Hiyama, H. Akiyama, Y. Wang and N. Koga, Chemical Physics Letters **577** (2013) 121.

11. Large enhancement of the photoluminescence emission of photoexcited undoped GaAs quantum wells induced by an intense single-cycle terahertz pulse: K. Shinokita, H. Hirori, K. Tanaka, T. Mochizuki, C. Kim, H. Akiyama, L. N. Pfeiffer and K. W. West, Phys. Rev. Lett **111** (2013) 067401.

12. Theoretical Study of Fluorescence Spectra Utilizing the pKa Values of Acids in Their Excited States: M. Hiyama, H. Akiyama, K. Yamada and N. Koga, Photochem. Photobiol **90** (2013) 35-40.

13. Low Threshold Lasing of GaN-Based VCSELs With Sub-Nanometer Roughness Polishing: W.-J. Liu, S.-Q. Chen, X.-L. Hu, Z. Liu, J.-Y. Zhang, L.-Y. Ying, X.-Q. Lv, H. Akiyama, Z.-P. Cai and B.-P. Zhang, IEEE Photon. Technol. Lett. **25** (2013) 2014.

14. Mode imaging and loss evaluation of semiconductor waveguides: T. Mochizuki, C. Kim, M. Yoshita, T. Nakamura, H. Akiyama, L. N. Pfeiffer and K. W. West, Rev. Sci. Instrum. **85** (2014) 053109.

15. Robust red-emission spectra and yields in firefly bioluminescence against temperature changes: T. Mochizuki, Y. Wang, M. Hiyama and H. Akiyama, Appl. Phys. Lett. **104** (2014) 213704.

16. Spectroscopic Study of Firefly Oxyluciferin in an Enzymatic Environment on the Basis of Stability Monitoring: Y. Wang, Y. Hayamizu and H. Akiyama, J. Phys. Chem. B **118** (2014) 2070–2076.

17. *Gain-switching dynamics in optically pumped single-mode InGaN vertical-cavity surface-emitting lasers: S. Chen, A. Asahara, T. Ito, J. Zhang, B. Zhang, T. Suemoto, M. Yoshita and H. Akiyama, Optics Express **22** (2014) 4196-4201.

18. Gain switching of a double-core-waveguide semiconductor laser via traveling-wave optical pumping: H. Nakamae, T. Nakamura, T. Ito, T. Mochizuki, C. Kim, S. Chen, M. Yoshita and H. Akiyama, Appl. Phys. Express **7** (2014) 062701.

19. *Spectral dynamics of picosecond gain-switched pulses from nitride-based vertical-cavity surface-emitting lasers: S. Chen, T. Ito, A. Asahara, M. Yoshita, W. Liu, J. Zhang, B. Zhang, T. Suemoto and H. Akiyama, Sci. Rep. **4** (2014) 4325.

20. Impact of Sub-cell Internal Luminescence Yields on Energy Conversion Efficiencies of Tandem Solar Cells: A design principle: L. Zhu, C. Kim, M. Yoshita, S. Chen, S. Sato, T. Mochizuki, H. Akiyama and Y. Kanemitsu, Applied Physics Letters **104** (2014) 031118.

† Joint research with outside partners.

I. Matsuda group

Developments and experiments of the advanced spectroscopies have been carried out by using vacuum ultraviolet (VUV) and soft X-rays (SX). At SPring-8 BL07LSU, picosecond-time-resolved SX photoemission spectroscopy measurements have been carried out to trace relaxation of photo-excited carriers at metal oxide surfaces. Analyses of the carrier life time have directly revealed the electron-hole recombination process. At Kashiwa campus, dynamics of the Dirac Fermion in a graphene layer is studied by femtosecond-time-resolved VUV photoemission spectroscopy. The transient electron temperature has indicated generation of the cascade carrier multiplication in the femtosecond-time scale. As a part of the undulator development at SPring-8 BL07LSU, phase shifters with electromagnetic coils were mechanically adjusted and installed in the electron storage ring. The phase shifters will be used to make fast polarization switching of the beamline.

1. Time-resolved photoelectron spectroscopies using synchrotron radiation: Past, present, and future: S. Yamamoto and I. Matsuda, J. Phys. Soc. Jpn. **82** (2013) 021003(1-18).

2. Electronic structure of the hydrogen-adsorbed $SrTiO_3$(001) surface studied by polarization-dependent photoemission spectroscopy: R. Yukawa, S. Yamamoto, K. Ozawa, M. D'Angelo, M. Ogawa, M. G. Silly, F. Sirotti and I. Matsuda, Phys. Rev. B **87** (2013) 115314(1-6).

3. Oscillatory relaxation of surface photovoltage on a semiconductor surface: M. Ogawa, S. Yamamoto, R. Yukawa, R. Hobara, L. -C. Huang, R. -Y. Liu, S. -J. Tang and I. Matsuda, Phys. Rev. B **87** (2013) 235308(1-4).

4. Relaxations of the surface photovoltage effect on the atomically controlled semiconductor surfaces studied by time-resolved photoemission spectroscopy: M. Ogawa, S. Yamamoto, K. Fujikawa, R. Hobara, R. Yukawa, Sh. Yamamoto, S. Kitagawa, D. Pierucci, M. G. Silly, C. -H. Lin, R. -Y. Liu, H. Daimon, F. Sirotti, S. -J. Tang and I. Matsuda, Phys. Rev. B **88** (2013) 165313(1-9).

5. Structure of silicene on a Ag(111) surface studied by reflection high-energy positron diffraction: Y. Fukaya, I. Mochizuki, M. Maekawa, K. Wada, T. Hyodo, I. Matsuda and A. Kawasuso, Phys. Rev. B **88** (2013) 205413(1-4).

6. 金属超薄膜内に閉じ込められた電子系のフェルミ面トポロジー制御 - 量子効果で銀細工：永村 直佳，小河 愛実，松田 巌，固体物理 **48** (2013) 13-19.

7. Anisotropic electronic conduction in metal nanofilms grown on a one-dimensional surface superstructure: N. Nagamura, R. Hobara, T. Uetake, T. Hirahara, K. Kobayashi, I. Matsuda and S. Hasegawa, Phys. Rev. B **89** (2014) 125415(1-5).

8. †*Observation of a giant Kerr rotation in a ferromagnetic transition metal by M-edge resonant magneto-optic Kerr effect: Sh. Yamamoto, M. Taguchi, M. Fujisawa, R. Hobara, S. Yamamoto, K. Yaji, T. Nakamura, K. Fujikawa, R. Yukawa, T. Togashi, M. Yabashi, M. Tsunoda, S. Shin and I. Matsuda, Phys. Rev. B **89** (2014) 064423(1-6).

9. *Observing hot carrier distribution in an n-type epitaxial graphene on a SiC substrate: T. Someya, H. Fukidome, Y. Ishida, R. Yoshida, T. Iimori, R. Yukawa, K. Akikubo, Sh. Yamamoto, S. Yamamoto, T. Yamamoto, T. Kanai, K. Funakubo, M. Suemitsu, J. Itatani, F. Komori, S. Shin and I. Matsuda, Appl. Phys. Lett. **104** (2014) 161103(1-4).

10. Non-linear kinetic model for oscillatory relaxation of the photovoltage effect on a Si(111)7x7 surface: M. Ogawa, R. -Y. Liu, C. -H. Lin, S. Yamamoto, R. Yukawa, R. Hobara, S. -J. Tang and I. Matsuda, Surf. Sci. **624** (2014) 70-75.

11. 反射高速陽電子回折(RHEPD)による Ag(111) 表面上のシリセンの構造決定：深谷 有喜，望月 出海，前川 雅樹，和田 健，兵頭 俊夫，松田 巌，河裾 厚男，PF News **32** (2014) 10-14.

12. 表面電子化合物：松田 巌，深谷 有喜，PF News **31** (2014) 33-37.

13. †Electron–Hole Recombination Time at TiO_2 Single-Crystal Surfaces: Influence of Surface Band Bending: K. Ozawa, M. Emori, S. Yamamoto, R. Yukawa, S. Yamamoto, R. Hobara, K. Fujikawa, H. Sakama and I. Matsuda, J. Phys. Chem. Lett. **5** (2014) 1953.

14. Rashba effects within the space charge layer of a semiconductor: C.-H. Lin, T.-R. Chang, Ro. -Ya. Liu, C.-M. Cheng, K.-D. Tsuei, H. -T. Jeng, C.-Y. Mou, I. Matsuda and S. -J. Tang, New. J. Phys. **16** (2014) 045003(1-12).

15. †*New soft X-ray beamline BL07LSU at SPring-8: S. Yamamoto, Y. Senba, T. Tanaka, H. Ohashi, T. Hirono, H. Kimura, M. Fujisawa, J. Miyawaki, A. Harasawa, T. Seike, S. Takahashi, N. Nariyama, T. Matsushita, M. Takeuchi, T. Ohata, Y. Furukawa, K. Takeshita, S. Goto, Y. Harada, S. Shin, H. Kitamura, A. Kakizaki, M. Oshima and I. Matsuda, J Synchrotron Rad **21** (2014) 352-365.

16. 量子井戸：松田 巌，「表面科学会教科書シリーズ 6　問題と解説で学ぶ表面科学」，松井文彦，(共立出版，2013), 88.

* Joint research among groups within ISSP.

Kobayashi group

We have demonstrated a precision spectroscopy in VUV region by using VUV frequency comb.

1. vuv frequency-comb spectroscopy of atomic xenon: A. Ozawa and Y. Kobayashi, Phys. Rev. A **87** (2013) 022507(1-4).
2. 6-GHz, Kerr-lens mode-locked Yb:Lu_2O_3 ceramic laser for comb-resolved broadband spectroscopy: M. Endo, A. Ozawa and Y. Kobayashi, Opt. Lett. **38** (2013) 4502.
3. 10-MHz, Yb-fiber chirped-pulse amplifier system with large-scale transmission gratings: Y. Kobayashi, N. Hirayama, A. Ozawa, T. Sukegawa, T. Seki, Y. Kuramoto and S. Watanabe, Optics Express **21** (2013) 12865.
4. Static FBG strain sensor with high resolution and large dynamic range by dual-comb spectroscopy: N. Kuse, A. Ozawa and Y. Kobayashi, Optics Express **21** (2013) 11141.
5. 光源としての光コム (2)　VUV 領域および高繰り返しコム：小林 洋平 , 分光研究 **62** (2013) 185.
6. 紫外光周波数コム発生と精密分光への応用：小澤 陽 , 小林 洋平 , OplusE **35** (2013) 1132.
7. デュアルコム分光 FT-IR にかわる高速広帯域精密分光：久世 直也 , 小澤 陽 , 小林 洋平 , 日本物理学会 **69** (2014) 29.

Itatani group

The Itatani group worked mainly on (i) the generation of soft-X-ray high harmonics using a BIBO-based optical parametric chirped pulse amplifier at 1.6 μm and (ii) the generation of intense THz pulses and their application to coherent control of small molecules. Regarding the BIBO-based source, we measured high harmonic spectra up to 330 eV with various experimental parameters such as backing pressures and carrier-envelope phases of the driver pulses. We observed clear CEP-dependences up to the backing pressure of 3 atm, which showed a potential to increase the photon flux of soft-X-ray attosecond pulses. As for the THz generation, we controlled the rotational wavepackets in jet-cooled HBr molecules to achieve molecular orientation (alignment with head-and-tail discrimination). We observed clear signature of molecular orientation by a newly-developed velocity-map imaging apparatus. This is the first clear demonstration of molecular orientation by using intense THz pulses.

1. †Orientation of jet-cooled polar molecules with an intense single-cycle THz pulse: K. Kitano, N. Ishii, N. Kanda, Y. Matsumoto, T. Kanai, M. Kuwata-Gonokami and J. Itatani, Phys. Rev. A **88** (2013) 061405.
2. †*Ultrafast photoinduced transition of an insulating VO_2 thin film into a nonrutile metallic state: R. Yoshida, T. Yamamoto, Y. Ishida, H. Nagao, T. Otsuka, K. Saeki, Y. Muraoka, R. Eguchi, K. Ishizaka, T. Kiss, S. Watanabe, T. Kanai, J. Itatani and S. Shin, Phys. Rev. B **89** (2014) 205114(1-7).
3. *Observing hot carrier distribution in an n-type epitaxial graphene on a SiC substrate: T. Someya, H. Fukidome, Y. Ishida, R. Yoshida, T. Iimori, R. Yukawa, K. Akikubo, Sh. Yamamoto, S. Yamamoto, T. Yamamoto, T. Kanai, K. Funakubo, M. Suemitsu, J. Itatani, F. Komori, S. Shin and I. Matsuda, Appl. Phys. Lett. **104** (2014) 161103(1-4).
4. †Carrier-envelope phase-dependent high harmonic generation in the water window using few-cycle infrared pulses: N. Ishii, K. Kaneshima, K. Kitano, T. Kanai, S. Watanabe and J. Itatani, Nat. Commun. **5** (2014) 3331.

Harada group

1) Operando soft X-ray RIXS spectroscopy for electronic structure analysis of catalytic reactions:: We have developed a novel electrochemical cell system for operando soft X-ray emission spectroscopy for analysis of catalytic reactions. We have applied the system to identify the active site for oxygen reduction reaction in polymer electrolyte fuel cells cathode catalysts. We have observed the electronic structure of iron in an iron phthalocyanine-based cathode catalyst under various working conditions and found that an oxidized iron site exists and is active for oxygen adsorption, which is not expected from ex situ results in which a metallic iron site dominates. 2) Development of the soft X-ray RIXS system around sample manipulation:: In order to extend the public use of the soft X-ray emission spectroscopy station we have realized precise temperature control of liquids in the range of -5 ~ 80 ^{o}C within ±1K accuracy using an originally developed thermal shielding, and surface cleaning by neutralized ion sputtering and annealing at more than 1000 K by electron bombardment. We also have implemented a liq. He sample cooling system down to 35 K. All these systems are now in operation and open to public. 3) Pioneering work on soft X-ray vibrational RIXS of liquids: Ultrahigh resolution resonant inelastic soft X-ray scattering was applied to observe multiple vibrational excitations in liquid water. By tuning X-ray excitation energy to a particular structure in the X-ray absorption spectrum we have successfully obtained vibrational frequencies well correlate with the OH stretching mode of a particular configuration of water. This enables element- and site-specific vibrational spectroscopy that is not accessible by the conventional IR or Raman spectroscopy.

† Joint research with outside partners.

1. †*Selective Probing of the OH or OD Stretch Vibration in Liquid Water Using Resonant Inelastic Soft-X-Ray Scattering: Y. Harada, T. Tokushima, Y. Horikawa, O. Takahashi, H. Niwa, M. Kobayashi, M. Oshima, Y. Senba, H. Ohashi, KT. Wikfeldt, A. Nilsson, LGM. Pettersson and S. Shin, Phys. Rev. Lett. **111** (2013) 193001(1-5).

2. *Resonant inelastic X-ray scattering of liquid water: A. Nilsson, T. Tokushima, Y. Horikawa, Y. Harada, M. P. Ljungberg, S. Shin and L. G. M. Pettersson, J. Electron Spectrosc. Relat. Phenom. **188** (2013) 84-100.

3. Probing carbon edge exposure of iron phthalocyanine-based oxygen reduction catalysts by soft X-ray absorption spectroscopy: H. Niwa, M. Saito, M. Kobayashi, Y. Harada, M. Oshima, S. Moriya, K. Matsubayashi, Y. Nabae, S. Kuroki, T. Ikeda, K. Terakura, J.-I. Ozaki and S. Miyata, Journal of Power Sources **223** (2013) 30-35.

4. * 液体水分子の内殻電子励起ダイナミクスと局所構造：原田 慈久 , 徳島 高 , 堀川 裕加 , 丹羽 秀治 , 木内 久雄 , 小林 正起 , 尾嶋 正治 , 辛 埴 , しょうとつ **10** (2013) 14-20.

5. Operando soft X-ray emission spectroscopy of iron phthalocyanine-based oxygen reduction catalysts: H. Niwa, H. Kiuchi, J. Miyawaki, Y. Harada, M. Oshima, Y. Nabae and T. Aoki, Electrochemistry Communications **35** (2013) 57-60.

6. †Unveiling the impurity band induced ferromagnetism in the magnetic semiconductor (Ga,Mn)As: M. Kobayashi, I. Muneta, Y. Takeda, Y. Harada, A. Fujimori, J. Krempaský, T. Schmitt, S. Ohya, M. Tanaka, M. Oshima and V. N. Strocov, Phys. Rev. B **89** (2014) 205204(1-8).

7. †Electronic Excitations of a Magnetic Impurity State in the Diluted Magnetic Semiconductor (Ga,Mn)As: M. Kobayashi, H. Niwa, Y. Takeda, A. Fujimori, Y. Senba, H. Ohashi, A. Tanaka, S. Ohya, P. N. Hai, M. Tanaka, Y. Harada and M. Oshima, Phys. Rev. Lett. **112** (2014) 107203(1-7).

8. †*Solvation dependence of valence electronic states of water diluted in organic solvents probed by soft X-ray spectroscopy: T. Tokushima, Y. Horikawa, O. Takahashi, H. Arai, K. Sadakane, Y. Harada, Y. Takata and S. Shin, Phys. Chem. Chem. Phys. **16** (2014) 10753.

9. †*New soft X-ray beamline BL07LSU at SPring-8: S. Yamamoto, Y. Senba, T. Tanaka, H. Ohashi, T. Hirono, H. Kimura, M. Fujisawa, J. Miyawaki, A. Harasawa, T. Seike, S. Takahashi, N. Nariyama, T. Matsushita, M. Takeuchi, T. Ohata, Y. Furukawa, K. Takeshita, S. Goto, Y. Harada, S. Shin, H. Kitamura, A. Kakizaki, M. Oshima and I. Matsuda, J Synchrotron Rad **21** (2014) 352-365.

10. †Iron-Nitrogen Coordination in Modified Graphene Catalyzes a Four-Electron-Transfer Oxygen Reduction Reaction: K. Kamiya, H. Koshikawa, H. Kiuchi, Y. Harada, M. Oshima, K. Hashimoto and S. Nakanishi, ChemElectroChem (2014), accepted for publication.

Wadati group

Our main experimental techniques are synchrotron-based x-ray spectroscopy and scattering. We studied the orbital and magnetic phase transitions in $Pr_{0.5}Ca_{0.5}MnO_3$ epitaxial thin films by resonant soft x-ray scattering and observed three phase transitions, one of which is absent in bulk $Pr_{0.5}Ca_{0.5}MnO_3$. We also studied the valence of Bi in Bi-based new-type superconductors by x-ray absorption spectroscopy and obtained evidence for the scenario of electron doping for the emergence of superconductivity.

1. Antiferromagnetic Order of the Co^{2+} High-Spin State with a Large Orbital Angular Momentum in $La_{1.5}Ca_{0.5}CoO_4$: J. Okamoto, H. Nakao, Y. Yamasaki, H. Wadati, A. Tanaka, M. Kubota, K. Horigane, Y. Murakami and K. Yamada, J. Phys. Soc. Jpn. **83** (2014) 044705.

2. Insulator-to-Superconductor Transition upon Electron Doping in a BiS_2 -Based Superconductor $Sr_{1-x}La_xFBiS_2$: H. Sakai, D. Kotajima, K. Saito, H. Wadati, Y. Wakisaka, M. Mizumaki, K. Nitta, Y. Tokura and S. Ishiwata, J. Phys. Soc. Jpn. **83** (2014) 014709.

3. Revealing orbital and magnetic phase transitions in $Pr_{0.5}Ca_{0.5}MnO_3$ epitaxial thin films by resonant soft x-ray scattering: H. Wadati, J. Geck, E. Schierle, R. Sutarto, F. He, D. G. Hawthorn, M. Nakamura, M. Kawasaki, Y. Tokura and G. A. Sawatzky, New J. Phys. **16** (2014) 033006.

* Joint research among groups within ISSP.

Kondo group

We use angle-resolved photoemission spectroscopy (ARPES) with ultrahigh energy resolution, achieved by using laser photon source, and study the nonconventional superconductors, heavy fermions, strongly correlated systems, topological quantum phases, and quantum well states. The main findings in 2013 are as follows: (1) Formation of Gapless Fermi Arcs and Fingerprints of Order in the Pseudogap State of Cuprate Superconductors. (2) Anomalous Dressing of Dirac Fermions in the Topological Surface State. (3) Significant doping Variation of the Nodal Low-Energy Feature of Superconducting $Bi_2Sr_2CuO_{6+\delta}$ (Bi2201) crystals.

1. †* Anomalous Doping Variation of the Nodal Low-Energy Feature of Superconducting $(Bi,Pb)_2(Sr, La)_2CuO_{6+\delta}$ Crystals Revealed by Laser-Based Angle-Resolved Photoemission Spectroscopy: T. Kondo, Y. Nakashima, W. Malaeb, Y. Ishida, Y. Hamaya, T. Takeuchi and S. Shin, Phys. Rev. Lett. **110** (2013) 217006(1-5).

2. †* Anomalous Dressing of Dirac Fermions in the Topological Surface State of Bi_2Se_3, Bi_2Te_3, and Cu-Doped Bi_2Se_3: T. Kondo, Y. Nakashima, Y. Ota, Y. Ishida, W. Malaeb, K. Okazaki, S. Shin, M. Kriener, S. Sasaki, K. Segawa and Y. Ando, Phys. Rev. Lett. **110** (2013) 217601(1-5).

3. Formation of Gapless Fermi Arcs and Fingerprints of Order in the Pseudogap State of Cuprate Superconductors.: T. Kondo, A. D. Palczewski, Y. Hamaya, T. Takeuchi, J. S. Wen, Z. J. Xu, G. Gu and A. Kaminski, Phys. Rev. Lett. **111** (2013) 157003(1-5).

4. †* Surface electronic structure of the topological Kondo-insulator candidate correlated electron system SmB_6: M. Neupane, N. Alidoust, S. -Y. Xu, T. Kondo, Y. Ishida, D. J. Kim, C. Liu, I. Belopolski, Y. J. Jo, T. -R. Chang, H. -T. Jeng, T. Durakiewicz, L. Balicas, H. Lin, A. Bansil, S. Shin, Z. Fisk and M. Z. Hasan, Nat. Commun. **4** (2013) 2991(1-7).

5. Fermi Surface and Pseudogap Evolution in a Cuprate Superconductor.: Y. He, Y. Yin, M. Zech, A. Soumyanarayanan, M. M. Yee, T. Williams, M. C. Boyer, K. Chatterjee, W. D. Wise, I. Zeljkovic, T. Kondo, T. Takeuchi, H. Ikuta, P. Mistark, R. S. Markiewicz, A. Bansil, S. Sachdev, E. W. Hudson and J. E. Hoffman, Science **344** (2014) 608-611.

† Joint research with outside partners.