物性研究所セミナー

標題：Feasibility study of quantum spin liquid in extensions of the Kitaev model
日時：2023 年 6 月 16 日(金) 午後 4 時～午後 5 時
場所：物性研究所 6 階第 5 セミナー室（A615）及び Online
講師：Dr. Kiyu Fukui
所属：Department of Applied Physics, The University of Tokyo
要旨：

The Kitaev model provides us with a rare example of exact quantum spin liquid (QSL) states in more than one dimension. While it is very important to explore new platforms for realizing the Kitaev QSL theoretically, extensions of the model make it no longer solvable and numerical calculations are challenging. Here we address the feasibility of the Kitaev QSL for three extensions of the model, by using the pseudofermion functional renormalization group method.

The first one is the extension to higher-spin systems [1]. We clarify the ground-state phase diagrams of the spin-S Kitaev-Heisenberg model systematically by changing the ratio between the Kitaev and Heisenberg interactions and the length of spin S. We find that the Kitaev QSL regions remain stable for $S < 2$, whereas the regions are quickly shrunk while increasing S.

The second one is the extension to three-dimensional (3D) systems [2]. Studying the Kitaev-Heisenberg model defined on a 3D hyperhoneycomb lattice, we show that the ground-state phase diagram is similar to the two-dimensional honeycomb case. Our results respect the four-sublattice symmetry inherent in the model, which was violated in the previous study.

The last one is for ultracold polar molecules trapped in an optical lattice [3]. We study a model proposed as an implementation of the Kitaev-type interactions, and clarify that the ground state is magnetically ordered. We also unravel how the Kitaev QSL is destabilized by the long-range interactions originating from the dipole interactions between polar molecules.

[1] K. Fukui, Y. Kato, J. Nasu, and Y. Motome, Phys. Rev. B 106, 174416 (2022).
[2] K. Fukui, Y. Kato, and Y. Motome, J. Phys. Soc. Jpn. 92, 064708 (2023).
[3] K. Fukui, Y. Kato, J. Nasu, and Y. Motome, Phys. Rev. B 106, 014419 (2022).
If you wish to participate online, please register here.

標題：Topological gap labeling in moire quasicrystals
日時：2023 年 6 月 23 日(金) 午後 4 時～午後 5 時
場所：Online and Lecture Room A632 , ISSP（Hybrid）
講師：Prof. Mikito Koshino
所属：Department of Physics, Osaka University
要旨：

Twisted 2D materials, consisting of rotationally stacked layers, can generally beregarded as quasi-periodic systems (quasicrystals)in that the systems have multipleperiodicitiesincommensurate with each other.Here we present a novel approach to characterizing energy gaps in 2D quasi-periodicsystems using a set of second Chern numbers. Theses numbers correspond to quantized Hall conductivity in a 4D system, which isconnected tothe original 2D quasicrystal

through a process of dimensional reduction. We apply the theory to hBN/graphene/hBN superlattice, where we find thattheelectronic spectrum exhibits fractal minigaps, and each of them is uniquely labeled bysix second Chern numbers. We also consider the bulk-edge correspondence in this system, and discover that thenumber of edge-states bands per unit length is determined by the second Chern numbersassociated with the gap.

[1] M. Koshino, H. Oka, Phys. Rev. Research 4, 013028(2022).
[2] H. Oka and M. Koshino, Phys. Rev. B 104, 035306 (2021).

標題：結晶構造探索手法およびソフトウェア開発
日時：2023 年 6 月 29 日(木) 午後 1 時～午後 2 時
場所：物性研究所 本館 6 階第 5 セミナー室(A615 号室)及び Online（Hybrid）
講師：山下 智樹
所属：長岡技術科学大学
要旨：

第一原理計算等を利用して安定構造を予測する手法は結晶構造探索（英語では crystal structure prediction: CSP）と呼ばれ、様々な分野における新物質・材料設計の基盤ツールとして期待されている。特に近年は、計算機能力の発達と機械学習をはじめとする情報科学的手法の適用の流れを受け、様々な探索アルゴリズムが提案されている。我々はベイズ最適化を用いた探索アルゴリズムの開発を皮切りに機械学習を用いた選択型アルゴリズムを開発した[1, 2]。また、誰でも簡単に結晶構造探索が行えるよう、Python 製プログラムの CrySPY をオープンソースソフトウェアとして公開している[3, 4]。CrySPY は VASP や Quantum ESPRESSO などの外部の第一原理計算ソフトおよび原子間ポテンシャル計算ソフトと連携することで結晶構造探索が可能であり、探索アルゴリズムとしてランダムサーチや進化的アルゴリズムをはじめ、機械学習を利用した選択型アルゴリズムが利用できる。各種アルゴリズムの探索効率やその実用性、結晶構造探索の難しさ、そして最近の開発状況や取り組みについて紹介した。

[1] T. Yamashita et al., Phys. Rev. Mater. 2, 013803 (2018).
[2] K.Terayama et al., npj Comput. Mater. 4, 32 (2018).
[3] T. Yamashita et al., Sci. Technol. Adv. Mater. Meth. 1, 87 (2021).
[4] https://github.com/Tomoki-YAMASHITA/CrySPY.

標題：ジャイロトロンを用いた金属磁性薄膜のサブ THz スピンダイナミクス評価
日時：2023 年 7 月 7 日(金) 午前 11 時～午後 0 時
場所：Online
講師：森山 貴広
所属：名古屋大学工学研究科
要旨：

反強磁性体やフェリ磁性体のテラヘルツ応答性の評価は古くから行われているが、そのほとんどがバルク結晶を対象としたもので、薄膜を対象とした評価はほとんど行われていない。テラヘルツで動作する反強磁性体・フェリ磁性体を用いたスピンデバイスは、近年発展が目覚ましい情報通信処理分野や超高速エレクトロニクスにおける次世代デバイスとして期待されており、デバイス応用に資する薄膜材料のテラヘルツ特性評価が急務になっている。本講演では、ジャイロトロンを利用したサブテラヘルツ帯における磁性薄膜の磁化ダイナミクスの測定結果について紹介した。

標題：Interplay of the electric dipoles and lattice degree of freedom in the triangular lattice Mott insulator κ-(BEDT-TTF)2Cu2(CN)3

日時：2023 年 7 月 11 日(火) 午前 11 時～午後 0 時

場所：第 5 セミナー室（A615）及び Online

講師：Prof. Natalia Drichko

所属：The Johns Hopkins University

要旨：

Molecular BEDT-TTF-based Mott insulators are unique S=1/2 triangular lattice antiferromagnets, where the electrons, which carry spin, can also produce an on-site electric dipole moment[1].

The interplay of the charge and spin degrees of freedom in κ-phase BEDT-TTF based salts is studied already for about a decade. κ-(BEDT-TTF)2Cu2(CN)3 is the most studied material of thisgroup, which was the first proposed triangular S=1/2 spin liquid candidate[2.3], but recently a low-temperature singlet state is suggested by some measurements[4]. There are still unsolved questions: Does κ-(BEDT-TTF)2Cu2(CN)3 develop charge disproportionation? How does it influence the spin degree of freedom? Can we control charge and spin degrees of freedom and their coupling by external stimuli?

Raman scattering spectroscopy is known to be a practical tool to study these problems, allowing to probe in one measurement the charge degrees of freedom by charge sensitive vibrations of ET molecule, magnetic excitations, and lattice phonons.

In our recent experiments we followed the behavior of lattice modes as well as charge sensitive vibrations in κ-(BEDT-TTF)2Cu2(CN)3 down to low temperatures. The analysis of the line shape of the charge sensitive molecular vibration shows a Gaussian line shape with broadening on cooling, pointing on the developing fluctuating charge disproportionation with disordered charge below approximately 40 K. Lattice modes respond to this change in the charge degree of freedom on BEDT-TTF molecule by an increase of intensity, which is a function of polarizability. Below approximately 20 K lattice modes associated with the BEDT-TTF vibrations signal the new changes: intensity starts to drop, an extra mode becomes active at 37 cm-1 in (b, c) scattering channel, in (c, c) channel BEDT-TTF lattice modes broaden considerably. We discuss how the observation suggest charge freezing and scattering of phonons on charge or spin-charge excitations.

1. N. Hassan, S. Cunningham, M. Mourigal, E. I. Zhilyaeva, S. A. Torunova, R. N. Lyubovskaya, J. A. Schlueter, and N. Drichko, Science, 360, 1101 (2018).
2. Y. Shimizu, K. Miyagawa, K. Kanoda, M. Maesato, and G. Saito, Phys. Rev. Lett, 91, 107001 (2003).
3. S. Yamashita, Y. Nakazawa, M. Oguni, Y. Oshima, H. Nojiri, Y. Shimizu, K. Miyagawa, and K. Kanoda, Nature Physics 4, 459 (2005).
4. B. Miksch, A. Pustogow, M. J. Rahim, A. A. Bardin, K. Kanoda, J. A. Schlueter, R. Hubner, M. Scheffler, and M. Dressel, Science 372, 276 (2021).

標題：Semiclassical ground state analysis of a two-dimensional trimerized quantum magnet
日時：2023 年 7 月 19 日(水) 午後 4 時～
場所：Online and Lecture room A615, ISSP (Hybrid)
講師：Dr. Yoshitomo Kamiya
所属：Shanghai Jiao Tong University
要旨：

In a quantum spin trimer system with half-integer spin, each trimer has a spin-1/2 responsible for magnetism and a pseudospin-1/2 responsible for electric polarization and scalar chirality, and their interplay is expected to induce a variety of different phases and multiferroic phenomena [1]. Although there are few experimental realizations compared to the well-studied quantum spin dimer systems, trimer systems have been realized in the so-called breathing kagome lattice and organic magnetic materials based on molecular magnets. In this informal talk, we will discuss our ongoing study of magnetization processes in the trimerized triangular lattice Heisenberg model using a semiclassical approach [2]. Despite only nearest-neighbor interactions, a series of incommensurate phases with field-dependent wavelengths are suggested over a wide range of external fields. Interestingly, the instability of a 1/3 magnetization plateau may be caused by a mechanism completely different from the well-known magnon BEC.

References:
[1] Y. Kamiya and C. D. Batista, Phys. Rev. Lett. 108, 097202 (2012).
[2] Z. Zhang and Y. Kamiya, in preparation.

標題：熱パルスを用いた急冷法による準安定電子相の開拓
日時：2023 年 7 月 21 日(金) 午前 11 時～午後 0 時
場所：Online
講師：大池 広志（さきがけ 専任研究者）
所属：物性研究所
要旨：

ガラス、ダイヤモンド、マルテンサイトなどは、自由エネルギー最小ではないにも関わらず安定に存在する準安定相の代表例である。このような準安定相は身の回りに数多く存在している一方で、物質中で相互作用する電子系の研究においては準安定相の存在はあまり注目されて来なかった。その背景には、電子は量子トンネルしながらフェムト秒スケールで運動するため、準安定相から最安定相にすぐに変化するだろうという推測があるように思われる。しかし、電子が多体的に相互作用したときの集団運動のダイナミクスは非自明であり、準安定相に留まる可能性も考えられる。本講演では、熱パルスを用いた急冷法によって、準安定磁気スキルミオン相や準安定超伝導相などの準安定電子相を開拓した研究を紹介する。これらの熱パルスによる研究成果を基に、超強磁場の実験で用いられるようなパルス磁場による準安定相の開拓の可能性についても言及した。

標題：ラマン分光法により明らかになった、 チャネルロドプシンのチャネル開閉メカニズム / Research on cathodes of lithium-ion batteries by synchrotron soft X-ray spectromicroscopy

日時：2023 年 7 月 24 日(月) 午後 1 時～午後 3 時

場所：Online

講師：（1）柴田 佳成 氏　（2）Zhang Wenxiong 氏

所属：物性研究所　井上研究室　原田研究室

要旨：

講師（1）：柴田 桂成 氏

題目：ラマン分光法により明らかになった、チャネルロドプシンのチャネル開閉メカニズム

概要：

チャネルロドプシン(ChR)は、7 本の膜貫通ヘリックスと発色団であるレチナールから構成される。ChR は光吸収に伴い光サイクル反応を示し、光受容イオンチャネルとして機能するため、光遺伝学の中心的なツールとして注目されている。しかし、チャネル開閉機構は未解明である。そこで我々は、チャネル開閉機構の解明を目的に、代表的な ChR である C1C2 におけるレチナールの構造を、時間分解ラマン分光法を用いて測定した。すべての光中間体における測定を行った結果、チャネル開状態においてレチナールが高度にねじること、そしてレチナールのねじれとプロトン化が、チャネル開閉を制御していることを明らかにした。

講師（2）：Zhang Wenxiong 張 文雄 氏

題目：Research on cathodes of lithium-ion batteries by synchrotron soft X-ray spectromicroscopy

概要：

Lithium-ion batteries (LIBs) are attracting attention as a promising technology to realize a low-carbon society. The performance of LIBs was mainly determined by the active materials of the cathode and anode. To fully understand the physical properties of cathode materials, it is essential to obtain the surface and bulk information on cathode materials and a better understanding of the electronic structure based on the Li-ion intercalation/deintercalation reactions. Synchrotron radiation facilities offer advanced capabilities for studying the chemical and electronic structure of cathode materials at high spatial and energy resolutions. By combining soft X-ray microscopy with spectroscopic techniques, it becomes possible to correlate local structural changes with the electronic and chemical properties of the cathode materials.

This report will elucidate the surface electronic structure of the prototypical LiCoO2 cathode particle by surface-sensitive microscopic resonant X-ray photoemission spectroscopy using 3DnanoESCA [1]. Meanwhile, the chemical-state changes of the individual LiCoO2 particles after the charging will be explained by bulk-sensitive microscopic absorption spectroscopy using scanning transmission X-ray microscopy (STXM) [2]. In addition, the air-oxidation nature of the olivine-type LiFe0.6Mn0.4PO4 nanowires with carbon sheath will be demonstrated by STXM [3]. Overall, synchrotron soft X-ray spectromicroscopy provides a powerful toolset for understanding the Li-ion intercalation/deintercalation mechanism of cathode materials in LIBs. It allows researchers to obtain detailed elemental, chemical, and structural information with high spatial resolution, enabling the development of more efficient and durable battery materials.

[1] Z. Wenxiong et al., CrystEngComm, 25, 183-188 (2023).

[2] Z. Wenxiong et al., Sci. Rep., 13, 4639 (2023).

[3] Z. Wenxiong et al., J. Electron Spectrsc. Relat. Phenom., 266, 147338 (2023).

標題：Generalized Skyrmions in spin-1 quantum magnets
日時：2023 年 7 月 28 日(金) 午後 4 時～
場所：物性研究所本館 6 階 第 5 セミナー室 (A615)
講師：Dr. Yutaka Akagi
所属：Department of Physics, Graduate Scholl of Science, The. University of Tokyo
要旨：

Skyrmions, which are representative of topological magnetism, have been studied intensively around the world since the successful direct observation of them in 2009. One of the reasons for the present interest in Skyrmions is that they are robust against perturbations owing to their nontrivial topology of spin configuration and are expected to lead to the development of magnetic storage devices with ultra-high density and ultra-low power consumption. On the other hand, in most studies on Skyrmions over the past decade, spins have been treated classically.

In such a trend, we studied topological magnetism in spin-1 quantum magnets. Using homotopy analysis and a numerical optimization technique, we have discovered a new type of Skyrmions (solitons) with emergent interactions in the S=1 bilinear biquadratic (BBQ) model on a triangular lattice at a global SU(3) symmetric point [1]. Recently, through interdisciplinary collaboration, we introduced a generalized Dzyaloshinskii- Moriya (DM) interaction to the S=1 BBQ model and constructed a stable isolated generalized (CP2) Skyrmion solution analytically [2]. By further investigation, we have also numerically found that generalized (CP2) Skyrmion crystals are stabilized as the ground state in S=1 quantum magnets with the generalized DM interaction [3].

The generalized Skyrmions show a nontrivial structure of not only dipole moments but also quadrupole moments and thus have no counterpart in the classical spin systems. In this seminar, we will discuss these generalized Skyrmions in detail.

[1] H. T. Ueda, Y. Akagi, and N. Shannon, Phys. Rev. A. 93, 021606(R) (2016).
[2] Y. Akagi, Y. Amari, N. Sawado, and Y. Shnir, Phys. Rev. D 103, 065008 (2021).
[3] Y. Amari, Y. Akagi, S. Gudnason, M. Nitta, Y. Shnir, Phys. Rev. B 106, L100406 (2022).

標題：生体膜のトポロジー変化：粗視化模型から何が分かるか？
日時：2023 年 7 月 31 日(月) 午後 4 時～午後 5 時
場所：物性研究所 本館 6 階第 5 セミナー室(A615 号室)及び Online
講師：Prof. Marcus Müller
所属：ゲッティンゲン大学
要旨：

The separation of an inside from an outside lies at the very heart of cellular life, and the organization of living organisms into cells and sub-cellular compartments is required for a large number of biological functions. This compartmentalization is maintained by lipid bilayers and undergoes frequent but carefully regulated topological changes, such as pore formation, fusion, and fission. Changes of membrane topology are involved in a variety of basic, cellular processes and require lipid rearrangements and transient formation of non-bilayer intermediate structures driven by curvature stress. We study the mechanisms of these processes by coarse-grained models, obtaining the minimum free-energy path via self-consistent field theory.

Division of intracellular organelles culminates with the scission of a highly constricted membrane neck. During fission, the tube first partially collapses into a worm-like micelle or hemifission (HF) intermediate, which then ruptures, resulting in two capped tubes. When unaided, the free-energy barriers for such remodeling can be prohibitively high,

so biological systems employ proteins as catalysts. Simply constricting the membrane aids the initial partial collapse, however, dynamin — a common fission protein — also inserts itself between head groups, distorting the membrane. Our results suggest that this distortion plays a critical role in reducing the free energy barrier to fission.

Fission often correlates with additional membrane wrapping, e. g. by the endoplasmic reticulum (ER) or the extra membrane of the mitochondrion. Such a wrapping plays a vital role in proteome and lipidome organization, yet its impact on the free-energy landscape of the fission process has largely remained unexplored. We investigate the stress-induced instabilities brought about by membrane wrapping in a simple double-membrane tubular system. We find that an outer membrane facilitates an alternative pathway for the fission of the inner tube at physiologically relevant membrane tensions. This alternative pathway results from a transient contact between the membranes of the inner and outer tube. A detailed study of the fission pathways in a double-membrane tubular system reveals the topological complexity of the process, resulting both in leaky and leakless intermediates.

標題：Disordered phases and Anderson transitions in non-Hermitian physics
日時：2023 年 8 月 25 日(金) 午後 4 時～午後 5 時
場所：Seminar Room 5 (A615), Hybrid
講師：Zhenyu Xiao
所属：Peking University
要旨：

Disordered non-Hermitian systems and Anderson transitions have received significant attention in recent studies. Before investigating non-Hermitian systems, we will review the application of random matrix theory, and Anderson transitions in closed quantum systems. Subsequently, we will demonstrate that the non-Hermitian random matrix theory can describe the complex spectra of non-integrable systems [1], wherein symmetry plays a pivotal role. Furthermore, we establish a correspondence between of Anderson transitions in non-Hermitian and Hermitian Hamiltonians [2]. It not only enables the reuse of existing knowledge but also inspires the exploration of Hermitian Anderson transitions. As an example, a non-Hermitian system without reciprocity can be mapped to a Hermitian counterpart featuring a weak topological index, which exhibits a “quasi-localized” phase and a new universality class of Anderson transitions [3].

Reference:
[1] Z. Xiao et al., Phys. Rev. Research 4, 043196 (2022).
[2] X. Luo et al., Phys. Rev. Research 4, L022035 (2022).
[3] Z. Xiao et al., arXiv:2211.09999 (to appear in Phys. Rev. Lett.).

標題：分散関係計測データに対するベイズパラメータ推定
日時：2023 年 9 月 1 日(金) 午後 4 時～午後 5 時
場所：物性研究所 本館 6 階第 5 セミナー室(A615 号室)及び Online
講師：片上 舜
所属：東京大学大学院 新領域創成科学研究科
要旨：

本研究では分散関係スペクトルデータから格子モデルパラメータをベイズ推定に基づき分布推定を行う。分散関係は中性子やX線を用いた非弾性散乱実験などで計測され、エネルギー輸送に関する性質や物理パラメータを解析する研究が多

く行われている。ここでは、分散関係計測データからベイズ推論およびレプリカ交換モンテカルロ法を用いて、格子モデルパラメータを推定する手法を提案する。また、提案手法を従来の解析手法と人工データを用いて比較し、手法の有効性を示す。人工データは体心立方格子モデルから得られた分散関係を中心とするローレンチアンの重ね合わせで強度を記述し、ポアソン過程に従って生成した。人工データ解析から、提案手法は格子モデルのモデルパラメータを信頼度付きで評価できる分布推定を可能とし、更に従来解析に比べて 1/100 程度の計測時間で適切な推論できることを示唆した。

標題：Photoredox organic transformations in water using Host-Guest Chemistry
日時：2023 年 9 月 11 日(月) 午後 3 時～午後 4 時 30 分
場所：物性研究所本館 6 階 第 5 セミナー室 (A615)
講師：Prof. Jyotishman Dasgupta
所属：Department of Chemical Sciences, Tata Institute of Fundamental Research, Mumbai, INDIA
要旨：

Enzymes are proteins that catalyze non-spontaneous organic reactions in physiological conditions. Remarkably the water-insoluble organic substrates are usually encapsulated in hydrophobic protein cavities, which constitute reaction hotspots in enzymes. We have devised a new catalytic photoredox paradigm using water-soluble cationic nanocages [1] that mimic the enzyme cavity while providing a modular host-guest photoactivation strategy. [2, 3] Through the potent combination of light activation and substrate pre-organization in water, we demonstrate facile yet selective aerobic oxidation of hydrocarbon C-H bonds under ambient conditions using proton-coupled electron transfer (PCET). [2, 4, 5, 6] In fact we have recently shown that we can translate this concept to all-organic nanocages. [7] The success of our designed artificial photoenzyme hints at the crucial role of electric fields in driving reactions within nanospaces.

[1] M. Fujita; Nature 1995, 378, 469–471.
[2] R. Gera, A. Das, A. Jha and J. Dasgupta*; J. Am. Chem. Soc. 2014, 136, 15909.
[3] A. Das, A. Jha, R. Gera and J. Dasgupta*; J. Phys. Chem. C 2015, 119, 21234–21242.
[4] A. Das, I. Mandal, R. Venkatramani, J. Dasgupta*; Science Advances 2019, 5, 2, eaav4806.
[5] S. Paul, A. Das and J. Dasgupta*; submitted
[6] S. Ghoshal, A. Das, D. Roy, and J. Dasgupta*; under revision
[7] D. Roy, S. Paul, and J. Dasgupta*; submitted

標題：A new old triangular lattice quantum magnet
日時：2023 年 9 月 12 日(火) 午後 2 時～午後 3 時
場所：物性研究所本館 6 階 第 5 セミナー室 (A615)及び Online
講師：Prof. Andrey Zheludev
所属：ETH Zurich, Switzerland
要旨：Abstract：

The distorted triangular lattice has long served as a vehicle for importing exotic one-dimensional physics into two dimensions. Using neutron diffraction and high-resolution neutron and THz spectroscopies we study the realization of this model in Cs2CoBr4, which additional features bond-dependent XY-anisotropy. At wave vectors where interchain interactions cancel out at the mean field level, the excitations are reminiscent of Zeeman ladders of bound kinks in individual chains. Elsewhere in the Brillouin zone the true two-dimensional structure and propagation of these modes are revealed. In applied magnetic fields the system goes through a zoo of peculiar phases. One is an incommensurate

spin density wave phase similar to that in spin-chains, where it is caused by spinon Fermi surface nesting and has a field-dependent propagation vector. Another is a fan-type structure, or what remains of a transverse-polarized helix in XY geometry, with the propagation vector set by the frustration ratio alone. Additional commensurate phases and extremely strong magneto-elastic effects are observed.

[1] L. Facheris, S. D. Nabi, A. Glezer Moshe, U. Nagel, T. Rõõm, K. Yu. Povarov, J. R. Stewart, Z. Yan, A. Zheludev, Confinement of fractional excitations in a triangular lattice antiferromagnet, Phys. Rev. Lett. 130, 256702 (2023).
[2] L. Facheris, K. Yu. Povarov, S. D. Nabi, D. G. Mazzone, J. Lass, B. Roessli, E. Ressouche, Z. Yan, S. Gvasaliya, A. Zheludev, Spin Density Wave vs. Fractional Magnetization Plateau in a Triangular Antiferromagnet, Phys. Rev. Lett. 129, 087201 (2022).
[3] K. Yu. Povarov, L. Facheris, S. Velja, D. Blosser, Z. Yan, S. Gvasaliya, A. Zheludev, Magnetization plateaux cascade in the frustrated quantum antiferromagnet Cs2CoBr4, Phys. Rev. Research 2, 043384 (2020).

標題：Tunable quantum interferometer of correlated moiré electrons
日時：2023 年 9 月 13 日(水) 午後 2 時～午後 3 時
場所：物性研究所本館 6 階 第 5 セミナー室 (A615)
講師：Shuichi Iwakiri
所属：ETH Zürich Nanophysics group (Prof. Klaus Ensslin)
要旨：

Magic angle twisted bilayer graphene (MATBG) exhibits a variety of gate-tunable correlated states, including superconductor and correlated insulator. Towards the understanding of charge, spin, and orbit nature of superconductivity and the coherence of moiré electrons, gate-defined devices such as Josephson junctions [1] and SQUIDs [2] have been realized. However, the complementary and fundamental coherence effects, namely the Little-Parks effect in superconducting and the Aharonov-Bohm effect in the normal conducting ring have yet to be observed.

Here, we develop a gate-defined ring in which a superconducting or normal conducting loop is surrounded by a correlated or band insulator [3]. This enables a direct observation of the Little-Parks effect in the superconducting phase diagram as a function of density and magnetic field, confirming the effective charge of 2e. We also determine the coherence length of normal conducting moiré electrons exceeding a few microns at 50 mK via the Aharonov-Bohm effect. Surprisingly, we find a regime that exhibits h/e-periodic oscillations but accompanied by a superconducting-like nonlinear transport. This work provides a new device platform in MATBG and tunable 2D materials, in general, to unravel the nature of superconductivity and other correlated states.

[1] F. de Vries et al., Nat. Nanotechnol. 16, 760–763 (2021).
[2] E. Portolés, S. Iwakiri, et al., Nat. Nanotechnol. 17, 1159–1164 (2022).
[3] S. Iwakiri, A. Mestre Torà, et al., submitted.