物性研究所セミナー

標題：極限コヒーレント光科学セミナー：The Challenges of University Startup: Mindset for Overcoming Crisis 大学発ベンチャーの挑戦 ~危機を乗り越えるマインドセット～

日時：2019 年 11 月 12 日(火) 午後 1 時～午後 3 時

場所：物性研究所本館 6 階 第一会議室(A636)

講師：セット ジイヨン

所属：東京大学 先端科学技術研究センター

要旨：

The speaker has been involved in a university startup since 2002, right at the beginning of the period when the Japanese government is calling and promoting Hiranuma plan to increase the number of university patents by 10 fold in 10 years, and a bold vision to create 1,000 university startups in 5 years. By 2006, 1,627 startups were created fulfilling the original vision.

The speaker will talk about the case study based on the speaker's experience in operating a university technology startup. The focus will be on a few technology commercialization stories, the challenges faced, and the required mindset to overcome them in order to build a sustainable and profitable company.

標題：量子物質・ナノスケールセミナー：Resonantly hybridized excitons in moiré superlattices in van der Waals heterostructures

日時：2019 年 11 月 12 日(火) 午後 2 時～午後 3 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. Alexander Tartakovskii

所属：Department of Physics and Astronomy, University of Sheffield, UK

要旨：

Recent years have seen significant effort in exploration of monolayer semiconductors such as transition metal dichalcogenides (TMDs) MoS2, WS2, MoSe2, WSe2 etc. Of particular interest is a possibility to combine few-atomic-layer crystals to create artificial heterostructures with tailored electronic and optical properties. This route opens possibilities inaccessible for traditional semiconductors, where the strict lattice matching requirement limits possible combinations of materials in a heterostructure. In contrast, atomically-thin layers of two-dimensional materials can be assembled in vertical stacks held together by relatively weak van der Waals forces, allowing for coupling between monolayer crystals with incommensurate lattices and arbitrary mutual rotation. The lattice constant difference and the mutual rotation angle present new degrees of freedom for the design of novel meta-materials.

A profound consequence of using these new degrees of freedom is the emergence of an overarching periodicity in the local atomic registry of the constituent crystal structures, known as a moiré superlattice. Its presence in graphene/hexagonal boron nitride structures led to observation of the Hofstadter butterfly spectra, and recently culminated in the discovery of the intriguing superconductor-insulator transition at magic twist angles. In my talk, I will show that in semiconducting heterostructures built of incommensurate MoSe2 and WS2 monolayers, excitonic bands can hybridize, which results in the resonant enhancement of the moiré superlattice effects. MoSe2 and WS2 are specifically chosen for the near degeneracy of their conduction band edges to promote the hybridization of intra- and interlayer excitons. For MoSe2/WS2 heterostructures with almost aligned pairs of monolayer crystals, the resonant

mixing of the electron states leads to amplified effects of the heterostructure's geometrical moiré pattern on the dispersion of the hybridised excitons. Further in my talk, I will also discuss the tuning of the band-structure in van der Waals heterostructures containing alloys such as MoxW1-xSe2, where novel hybridisation and moiré superlattice effects are also observed.

Sheffield 2D Materials group web-site: https://ldsd.group.shef.ac.uk/research/2d-materials/

References:

1. E. M. Alexeev, D. A. Ruiz-Tijerina, M. Danovich, M. J. Hamer, D. J. Terry, P. K. Nayak, S. Ahn, S. Pak, J. Lee, J. I. Sohn, M. R. Molas, M. Koperski, K. Watanabe, T. Taniguchi, K. S. Novoselov, R. V. Gorbachev, H. S. Shin, V. I. Fal'ko & A. I. Tartakovskii, "Resonantly hybridized excitons in moiré superlattices in van der Waals heterostructures", NATURE 567, 81 (2019).
2. A. Catanzaro, A. Genco, A. Kozikov, L. Sortino, C. Louca, D. Gillard, E. Alexeev, R. Pisoni, L. Hague, K. Einsslin, K. S. Novoselov, A. I. Tartakovskii, "Resonant electronic and excitonic hybridisation in heterobilayers made from transition metal dichalcogenides alloys", unpublished.

標題：ナノサイエンスセミナー：Fe-based superconducting thin films: current status and new perspective
日時：2019 年 11 月 27 日(水)　午後 1 時 30 分～午後 2 時 30 分
場所：物性研究所本館 6 階 第 5 セミナー室(A615)
講師：Professor Silvia Haindl
所属：Institute of Innovative Research, Tokyo Institute of Technology
要旨：

Thin films of Fe-based superconductors (Fe-pnictides, Fe-chalcogenides) have been synthesized and studied for about one decade in more than 500 publications. Despite the plethora of compounds within the family of new superconductors, the majority of thin film studies focused on FeSe (FeSe1-xTex) and BaFe2-xCoxAs2, because these compounds could be grown easily and successfully by pulsed laser deposition (PLD) and they showed, furthermore, high critical current densities (105 – 106 Acm-2) at liquid helium temperatures. Ultrathin Fe-chalcogenide films show also an electrostatic doping effect in electric-double-layer-transistor devices. In addition, the boost of transition temperature to 65 – 75 K in monolayer FeSe films grown by molecular beam epitaxy (MBE) has raised many new questions on the superconducting mechanism. Thin films of the more complex, layered anion compounds of Fe-oxyarsenides are less investigated because their synthesis is more difficult. Recently, progress was made in growing Fe-oxyarsenides and new heterostructures including different types of pnictide layers by using PLD. After giving an overview about the current status of thin film growth of the different Fe-based superconductors I will turn towards selected own investigations. Besides the conventionally explored high-field applications, new perspectives for Fe-based superconductors in the field of electronic devices will be discussed.

標題：機能物性セミナー：Molecular Devising and Device Engineering of Organic Electronics
日時：2019 年 11 月 28 日(木) 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：Prof. Hong Meng
所属：北京大学
要旨：

Organic electronics based on the thin film devices, including organic thin film transistors (OTFTs), organic light emitting diodes (OLEDs), organic photovoltaics (OPVs) and organic electrochromic devices (OECs) are envisioned both great interest in academia and industry. The properties of organic semiconductor materials are directly governed by the molecule structures. In this talk I will present the recent work conducted in our lab for molecule design strategies. Examples include searching high mobility organic semiconductors and dielectric materials (~50 cm2/Vs with Vt of 0.5 V) with unique properties for OTFT and OLED applications; high fluorescence and fine tuning color efficiency of electrochromic materials with D-A conjugated polymers for dual-mode display and military camouflage applications; energy level controlling of hole transport materials and interface engineering of materials for perovskite solar cell applications. Detailed studies on the electrochemical and photoelectronic properties as well as the device performance of these new semiconductors and interface materials are discussed, last I will share stories of our new discovery of AC-Planar electroluminescent devices.

標題：理論セミナー：Proof of absence of local conserved quantity in S=1/2 XYZ chain with a magnetic field
日時：2019 年 11 月 29 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)
講師：白石 直人
所属：学習院大学
要旨：

The distinction of integrability and non-integrability, which are strongly related to the notion of chaos, plays a pivotal role in quantum many-body physics. Integrability and non-integrability are roughly equivalent to the presence and the absence of local conserved quantities. The presence of local conserved quantities prevents thermalization and mixing, which are relevant to broad research fields including the application of the Kubo formula [1], transport properties [2], and the scrambling in a black hole [3]. Since integrable systems have some unphysical properties as explained above, almost all many-body systems in nature are considered to be non-integrable. Therefore, it is a surprise that no concrete quantum many-body system has been proven to be non-integrable in spite of its ubiquitousness. Even worse, some researchers believe that non-integrability is out of scope of analytical investigation, and non-integrability can be only presumed with help of numerical simulations. To overcome this pessimistic belief, in this presentation, we rigorously prove that a particular quantum many-body system, the spin-1/2 XYZ chain with a magnetic field, is indeed non-integrable in the sense that this system has no nontrivial local conserved quantity [4]. The proof of non-integrability exploits a bottom-up approach, in which we demonstrate that all the candidates of local conserved quantities cannot be conserved. Any nontrivial conserved quantity in this model turns out to be a sum of operators supported by at least half of the entire system. Our approach can apply to other S=1/2 systems including the Heisenberg model with the next nearest-neighbor interaction.

References:
[1] M. Suzuki, Physica 51, 277 (1971), A. Shimizu and K. Fujikura, J. Stat. Mech. 024004 (2017).
[2] X. Zotos, F. Naef, and P. Prelovsek, Phys. Rev. B 55, 11029 (1997).
[3] S. H. Shenker and D. Stanford, J. High Energ. Phys. 2014:67 (2014).
[4] N. Shiraishi, arXiv:1803.02637

標題：ナノサイエンスセミナー：Resolving atomic motions on a crowded surface
日時：2019 年 12 月 4 日(水) 午後 3 時～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：Professor Joost Wintterlin
所属：Ludwig-Maximilians-Universität München
要旨：

Using a combined high speed-variable temperature STM we have resolved the diffusion of adsorbed atoms on a surface completely covered by co-adsorbed molecules. This process, diffusion on a crowded surface, is important in heterogeneous catalysis because it randomizes the adsorption layer and is thus the basis for the reaction kinetics. O atoms on a completely CO-covered Ru(0001) surface were observed to move across the surface almost as fast as on the bare ruthenium surface. This effect cannot be explained by one of the diffusion mechanisms known from 3D solids, namely vacancy diffusion, interstitial diffusion, direct exchange, ring exchange, etc. A new lattice diffusion mechanism is proposed in which fast density fluctuations in the adsorption layer frequently open low-energy pathways for the travelling atom. The mechanism may play a general role in heterogenous catalyis.

標題：ナノサイエンスセミナー・機能物性セミナー：機能物性&ナノサイエンスセミナー（FHI から 3 名の講演）
日時：2019 年 12 月 5 日(木) 午後 2 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：(1) Ralph Ernstorfer (2) Mariana Rossi (3) Takashi Kumagai
所属：Fritz-Haber Institute of the Max-Planck Society, Berlin, Germany
要旨：

マックス・プランク協会フリッツ・ハーバー研究所の 3 名の研究者が物性研究所を来所し、連続セミナーを行います。

(1) Dr. Ralph Ernstorfer “Hot carrier and phonon dynamics in semiconductors investigated with trARPES and femtosecond electron diffraction” 14:00-14:45
(2) Dr. Mariana Rossi “Elucidating anharmonic quantum nuclear effects in hydrogen dynamics at finite temperatures” 14:45-15:30
(3) Dr. Takashi Kumagai “Near-Field Physics and Chemistry in Plasmonic STM junctions” 15:30-16:15

標題：理論セミナー：Heat- and laser-driven non-equilibrium transport in quantum magnets

日時：2019 年 12 月 6 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)

講師：佐藤 正寛

所属：茨城大学理学部

要旨：

In the last decades, non-equilibrium phenomena have been intensively explored and several theoretical methods treating them have been developed. Spintronics, electronics, mesoscopic physics, non-equilibrium statistical physics, multiferroics, optics, cold atoms, etc. have abundantly contributed to the development. Motivated by these progresses, in recent years, we have tried to find/explore new interdisciplinary topics among these fields, especially, focusing on heat- [1,2,3] or laser-driven [4,5,6] phenomena.

In the present seminar, I would like to report two of our recent results for non-equilibrium spin transport. The first topic is the spin Seebeck effect in a spin-nematic state [3]. This offers a route between spintronics and quantum magnetism. The second is the theoretical study of the laser-driven rectification of DC spin current in non-centrosymmetric magnetic insulators [5]. This study is the first proposal for the spin-current version of shift current (spin version of solar cell), and results from connecting several ideas in spintronics, optics, multiferroics, and non-equilibrium physics. I would like to explain these results focusing on their essential aspects.

[1] D. Hirobe, MS, et al, Nat. Phys. 13, 30 (2017).

[2] D. Hirobe, MS, et al, PRB95, 241112(R) (2017). Editor's Suggestion.

[3] D. Hirobe, MS, et al, PRL123, 117202 (2019).

[4] H. Fujita and MS, PRB95, 054421 (2017), Editor's suggestion; PRB96, 060407(R) (2017); Sci. Rep. 8, 15738 (2018); H. Fujita, Y. Tada, and MS, New. J. Phys. 21, 073010 (2019).

[5] H. Ishizuka and MS, PRL122, 197702 (2019); arXiv:1907.02734.

[6] T. N. Ikeda and MS, arXiv:1910.00146.

標題：ナノサイエンスセミナー：XTIP - A dedicated beamline for synchrotron X-ray scanning tunneling microscopy

日時：2019 年 12 月 9 日(月) 午後 1 時 30 分～午後 2 時 30 分

場所：物性研究所本館 6 階 第 5 セミナー室(A615)

講師：Dr. Nozomi Shirato

所属：Center for Nanoscale Materials, Argonne National Laboratory

要旨：

A result of combining synchrotron X-ray radiation and scanning probe microscopy is a powerful microscope which can image and examine materials with unprecedented details. Synchrotron X-ray scanning tunneling microscopy (SX-STM) is designed for real space imaging of objects on a surface at the atomic limit and simultaneously obtaining electronic, chemical or magnetic contrast. At Advanced Photon Source in Argonne National Laboratory, XTIP beamline, the world's first dedicated beamline for SX-STM has been constructed. The beamline mainly consists of circular and linear polarizer with switching rate of 1Hz, a spherical grating monochromator with more than 4000 resolving power and KB mirrors to focus beam down to tens of micrometer. The beamline can produce a photon flux of 1011-1013 photons per second at 1keV. The capabilities of the beamline will benefit the communities to explore chemical, magnetic and electronic properties of materials at atomic resolution. Recently, a commissioning of the beamline has

been conducted, and in this talk, preliminary status of the beamline and measurements from commissioning will be discussed.

標題：理論セミナー：Magnetic properties in the generalized Kitaev model
日時：2019 年 12 月 13 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：古賀 昌久
所属：東京工業大学理学院物理学系
要旨：

The Kitaev model [1] have attracted much interest in condensed matter physics since the possibility of direction-dependent Ising interactions has been proposed in realistic materials [2]. One of the important features characteristic of the Kitaev models is the fractionalization of the spin degree of freedom. In the Kitaev model with S = 1/2 spins, the spins are exactly shown to be fractionalized into itinerant Majorana fermions and localized fluxes. Two energy scales for distinct degrees of freedom yield interesting finite temperature properties, such as a double-peak structure in the specific heat and plateau in the entropy [3]. This fractionalization is closely related to the existence of the local Z2 symmetry in the system.

The existence of the local Z2 symmetry is known even in the generalized spin-S Kitaev model [4], while it is still unclear whether or not the spin fractionalization occurs in the system. To clarify this, in this study, we examine thermodynamic properties in the generalized Kitaev model by means of the thermal pure quantum state method. We then clarify the existence of the double-peak structure in the specific heat and plateau in the entropy [5]. These suggest the existence of fractionalization even in this spin-S Kitaev model. Magnetic properties in the mixed-spin Kitaev model are also discussed.

[1] A. Kitaev, Ann. Phys. 321, 2 (2006).
[2] G. Jackeli and G. Khaliullin, Phys. Rev. Lett. 102, 017205 (2009).
[3] J. Nasu, M. Udagawa, and Y. Motome, Phys. Rev. B 92, 115122 (2015).
[4] G. Baskaran, D. Sen, and R. Shankar, Phys. Rev. B 78, 115116 (2008).
[5] A. Koga, H. Tomishige, and J. Nasu, J. Phys. Soc. Jpn. 87, 063703 (2018).

標題：極限コヒーレント光科学セミナー：誤り耐性量子コンピュータの実現に向けて ～連続量光量子情報処理
日時：2019 年 12 月 17 日(火) 午後 3 時～午後 4 時 30 分
場所：物性研究所本館 6 階 第一会議室(A636)
講師：遠藤 護
所属：東京大学大学院工学系研究科物理工学専攻
要旨：

量子重ね合わせ状態や量子エンタングルメント状態という、量子力学特有の性質を巧みに利用した量子コンピュータは、処理すべき情報量が爆発的に増大する現代社会において渇望されている。Google の研究チームが量子超越性に関する論文を発表するなど、特に最近では大きく着目されている[1]。実際、Shor の素因数分解アルゴリズム、Grover の探索アルゴリズムなどの量子アルゴリズムを量子コンピュータで実装することで、非常に高速な計算が可能となることが知られている。しかし、上記アルゴリズムを現実的に行うことができる誤り耐性量子コンピュータが実現するのは 20 年後以降とされ[2]、技術的・理論的な課題は数多く残されているのが現状である。

本セミナーの冒頭では、こうした状況を整理する意味も込めて、量子コンピュータの概要を示し、誤り耐性量子コンピュータ実現に向けた世界各国の取り組みについても俯瞰する。

次に、我々のグループで注力している光の直交位相振幅に量子状態をエンコードする連続量光量子情報処理を紹介する。現在の量子コンピュータ研究の主流である超伝導トランズモン方式や、イオントラップ方式と比較して、光を用いる手法はスケーラビリティが高く、室温環境下でも動作し、さらに光通信技術との親和性が非常に高い、といった特徴を持つ。本セミナーでは、その中でも①時間多重大規模量子エンタングルメント状態生成[3]と、②全光量子メモリ[4]、に関する直近の成果を紹介したい。

[1] F. Arute et al, Nature 574, 505-510 (2019)
[2] 日本経済新聞電子版 2019 年 11 月 22 日「量子コンピューター、20 年で実用化　政府ロードマップ」
[3] W. Asavanant et al, Science 366, 373-376 (2019)
[4] Y. Hashimoto et al, PRL 123, 113603 (2019)