物性研究所セミナー

標題：理論セミナー：Twisted Schwinger effect
日時：2020 年 7 月 17 日(金)　午後４時～
場所：Zoom 開催
講師：岡　隆史
所属：東京大学物性研究所、マックスプランク複雑系物理学研究所
要旨：

We study the nonperturbative pair production of particles induced by strong rotating electric fields [1]. The excitations by tunneling become strongly chirality dependent due to nonadiabatic geometric effects. The threshold, i.e., Schwinger limit, even vanishes for particles with an optically allowed chirality. We explain these phenomena through the twisted Landau-Zener model proposed by M. V. Berry, and provide a quantitative understanding in terms of the geometric amplitude factor. As a condensed matter application, we make a nonperturbative analysis on the optically induced valley polarization in 2D Dirac materials. Furthermore, in 3D Dirac and Weyl materials with spin-orbit coupling, we predict the generation of a nonlinear spin or charge current in the direction of the laser propagation.

[1] Takayoshi, Wu, Oka, arXiv:2005.01755

標題：理論セミナー：Investigation of quantum spin liquids with symmetric PEPS
日時：2020 年 10 月 2 日(金)　午後４時～
場所：Zoom 開催
講師：Dr. Ji-Yao Chen
所属：Max-Planck-Institute of Quantum Optics
要旨：

Quantum spin liquid state can be represented and efficiently characterized within the symmetric Projected Entangled Pair State (PEPS) framework. A prototypical example is the nearest neighbor (NN) resonating valence bond (RVB) state, which has been thoroughly studied on various lattices with PEPS. Here I will show, through suitable deformation of the local tensor of NN RVB state on square lattice, we can introduce long-range singlets into the wave function and drive the state into a topological Z_2 phase. This approach turns out to be quite general for quantum spin liquid problem, which I will briefly explain. Then I will present our recent work about SU(3) chiral spin liquid using this approach, where characteristic feature of SU(3)_1 chiral topological order is observed from PEPS entanglement spectrum.

標題：理論セミナー：Atomistic approach to the Nd-Fe-B magnet − Coercivity at finite temperatures −
日時：2020 年 10 月 9 日(金)　午後 4 時～
場所：Zoom **開催**
講師：宮下 精二
所属：東京大学物性研究所
要旨：

The magnet, i.e., the permanent magnet, is a familiar material, and various magnets play important roles in many products such as electric motor and recording material. Analyses on its mechanism and improvements of the performance have been studied extensively. In particular, it is very important to study its temperature dependence. However, when we study the problem by methods of current physics, there are many interesting but difficult problems. Here we introduce our trials on this problem for the high-performance Nd2Fe14B.

For this purpose, first we constructed an atomistic Hamiltonian to take into account the temperature property. With it we calculated various thermodynamic quantities such as the magnetization and anisotropy energies by standard methods of statistical physics and confirmed the model can reproduce experimental results. Moreover, the domain wall profiles and the spectrum of FMR (ferromagnetic resonance) were also studied. As a merit of the atomistic model, we can find anisotropy due to the crystal structure and also atom-specific ordering properties.

The most important property is the coercivity. However, in contrast to the abovementioned thermodynamic quantities, we do not have theoretical formula and thus so far only little study has been done on the quantitative estimation of the coercivity at finite temperatures. Coercivity is a kind of spinodal phenomena. In systems of short-range interaction, however, there is no spinodal singularity at finite temperatures due to the nucleation. Therefore, we must study “spinodal-like” phenomena. We first studies this problem in nano-size grains by the stochastic LLG equation (Nishino, NIMs) and also by a method using the free-energy landscape obtained by Wang-Landau method (Toga, ISSP), and obtained the strength of field at which the relaxation of the magnetization reverse is 1 second (a definition of coercivity), and its temperature dependence. For larger grains, the dipole-dipole interaction plays a role and the so-called multidomain magnetic structure appears. To study such cases, we developed a modified SCO (stochastic cutoff) method and studied coercivity in such systems (Hinokihara, ISSP). The magnet is an ensemble of grains. Trials for such complicated case is also introduced.

標題：理論インフォーマルセミナー：Some Comments on the Anomalies of Fusion Category Symmetries
日時：2020 年 10 月 13 日(火)　午後 3 時～
場所：Zoom **開催**
講師：Yunqin Zheng
所属：Kavli IPMU / ISSP, The University of Tokyo
要旨：

In $1+1$d, the fusion category symmetry generalizes the concept of global symmetry. Akin to ordinary global symmetry, the fusion category symmetry can also suffer from ‘t Hooft anomalies.

We describe a criteria of when the ‘t Hooft anomaly is non-trivial from the data that describes the fusion category. This criteria generalizes the one from [1802.04445]. We also comment on how the anomalous theory couples to a non-invertible TQFT in one dimension higher.

標題：理論セミナー：原子層物質におけるスピン輸送現象
日時：2020 年 10 月 16 日(金)　午後４時～午後５時
場所：Zoom 開催
講師：大湊 友也
所属：中国科学院大学カブリ理論科学研究所
要旨：

原子層物質は 2 次元性に由来する特徴的な物性や積層によって電子構造が大きく変化する点に着目されており精力的に研究が進められている。原子層物質を磁性体上に積層させることで新奇なスピン物性の発現が期待されている。

本セミナーでは最近の二つの研究成果について解説する。一つ目の研究では、グラフェンを積層した強磁性絶縁体における磁化ダイナミクスについて調べた[1]。グラフェンと強磁性絶縁体の界面における磁気的近接効果によってギルバート緩和定数は変調される。本研究でギルバート緩和変調はグラフェンのフェルミレベルにおけるアップスピンとダウンスピンの状態密度の積に比例することを明らかにした。また、ランダウ量子化が生じる磁場領域ではギルバート緩和変調は磁場の関数として振動することを示した。この振動周期を解析することによって磁気的近接効果の相互作用定数を見積もることができる。

二つ目の研究では、強磁性絶縁体に単層遷移金属ダイカルコゲナイド(TMDC)を積層した系におけるスピンポンピングとスピン拡散について調べた[2]。TMDC はスピンとバレーが結合したバンド構造を持つ。このバンド構造を利用することで、フェルミレベルを適切に調節するとバレー選択的なスピンポンピングが可能であることを示した。それによってバレー偏極したスピン蓄積が生じる。バレー偏極したスピンの拡散を考察することで、縦スピン流によって横スピン蓄積が生じる”スピン流ホール効果”が起こることを示した。

[1] Y. Ominato and M. Matsuo, J. Phys. Soc. Jan. 89, 053704 (2020).
[2] Y. Ominato, J. Fujimoto, and M. Matsuo, Phys. Rev. Lett. 124, 166803 (2020).

標題：LASOR セミナー：Tunneling into emergent topological matter
日時：2020 年 11 月 19 日(木)　午前 10 時 30 分～
場所：Zoom 開催
講師：Dr. Jiaxin Yin
所属：Department of Physics, Princeton University
要旨：

The search for topological matter is evolving towards strongly interacting systems including topological magnets and superconductors, where novel effects emerge from the quantum level interplay between geometry, correlation, and topology. Equipped with unprecedented spatial resolution, electronic detection, and magnetic tunability, scanning tunneling microscopy has become an advanced tool to probe and discover the emergent topological matter. In this talk, I will review the proof-of-principle methodology to study the elusive quantum topology in this discipline, with particular attention on the studies under a vector magnetic field as the new direction, and project future perspectives in tunneling into other hitherto unknown topological matter [1-7].

1. Jia-Xin Yin et al. Nature 583, 533-536 (2020).
2. Jia-Xin Yin et al. Nature 562, 91-95 (2018).
3. Jia-Xin Yin et al. Nature Physics 15, 443–448 (2019).
4. Jia-Xin Yin et al. Nature Physics 11, 543 (2015).
5. Jia-Xin Yin et al. Phys. Rev. Lett. 123, 217004 (2019).
6. Jia-Xin Yin et al. Nature Communications 11, 4003 (2020).
7. Jia-Xin Yin et al. Nature communications 11, 4415 (2020).

標題：理論セミナー：Probing Floquet topological invariants with ultracold atoms

日時：2020 年 11 月 20 日(金)　午後４時～午後５時

場所：Zoom 開催

講師：Prof. Andre Eckardt

所属：ベルリン工科大

要旨：

The classification of topological Floquet systems with time-periodic Hamiltonians transcends that of static systems. For example, spinless fermions in periodically driven two-dimensional lattices are not completely characterized by the Chern numbers of the quasienergy bands, but rather by a set of winding numbers associated with the quasienergy gaps [Rudner et al. PRX 3, 031005 (2013)]. I will present two schemes for probing these winding numbers in experiments with ultracold atoms in driven optical lattices. The first one relies on the tomography of band-touching singularities occurring when adiabatically connecting the driven system to a trivial high-frequency regime [1,2] . The second one is based on observing the far-from-equilibrium micromotion of the driven system over two driving periods after a sudden quench into the target Hamiltonian [3]. It relies on the identification of the winding numbers with an Hopf invariant characterizing the micromotion operator.

[1] How to Directly Measure Floquet Topological Invariants in Optical Lattices, FN Ünal, B Seradjeh, A Eckardt, Phys. Rev. Lett. 122, 253601 (2019).

[2] Realization of an anomalous Floquet topological system with ultracold atoms, K Wintersperger, C Braun, FN Ünal, A Eckardt, M Di Liberto, N Goldman, I Bloch, M Aidelsburger, Nat. Phys. 16, 1058 (2020).

[3] Hopf characterization of two-dimensional Floquet topological insulators, FN Ünal, A Eckardt, RJ Slager, Phys. Rev. Research 1, 022003(R) (2019).