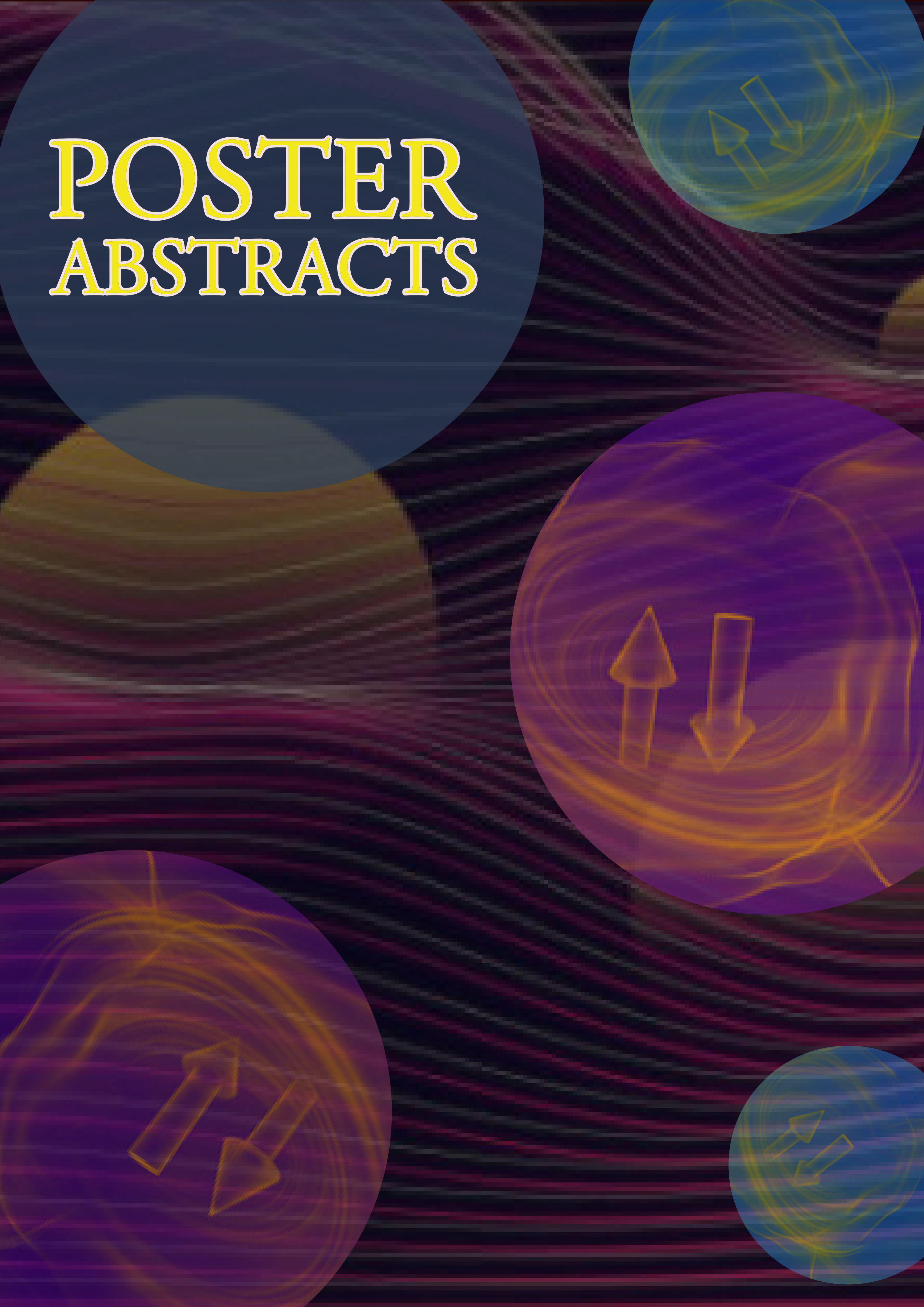
POSTER
ABSTRACTS

Substitution-Driven Enhancement of the Néel Temperature in the Noncollinear Magnet Mn_3Sn: A Theoretical Study

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Abstract

The noncollinear magnet Mn_3Sn is a key material for the realization of the antiferromagnetic devices. The magnetic symmetry, which is strongly related to topological properties in momentum space, has led to the observation of the anomalous Hall and Nernst effects [1] and even the antiferromagnetic tunnel magnetoresistance (TMR) in an antiferromagnetic material [2]. The history of ferromagnetic studies implies that thermal fluctuations at the interface with insulators degrade the TMR effect in the antiferromagnetic system. Therefore, from an application standpoint, we anticipate further increasing the Néel temperature of Mn_3Sn, usually 420 K, is highly important.

This theoretical study aims to find suitable elemental substitutions that may enhance the Néel temperature in Mn_3Sn. In order to obtain the exchange couplings of the substitution systems, we use Liechtenstein's formula and the coherent potential approximation (CPA), which have been implemented on the first-principles calculation using the Korringa-Kohn-Rostoker (KKR) Green's-function method, AkaiKKR [3]. Then, we built a classical spin model and performed Monte Carlo analysis to determine the Néel temperature in the substituted systems (see Figure).

In the presentation, we will discuss the possibility of enhancing the Néel temperature of Mn_3Sn by elemental substitutions and its structural stability.

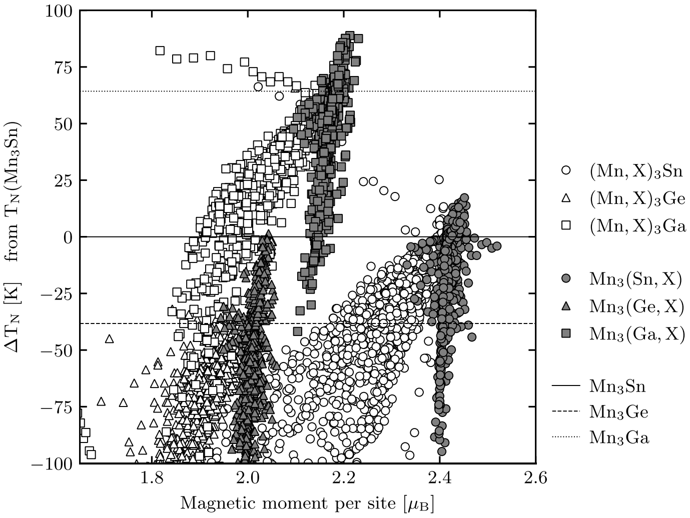

Fig. Theoretical estimate of variation in the Néel temperature of Mn_3Sn with elemental substitution.

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Anomalous Nernst effect in topological $Fe_3Ga_{1-x}Al_x$ polycrystals

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The anomalous Nernst effect (ANE) is the thermoelectric generation of a transverse voltage mutually perpendicular to both the magnetization and heat current in magnetic materials. Recently, the material discovery and device design based on ANE attracted a lot of attention due to its unique advantages of high efficiency and flexible structure [1]. A series of stoichiometric topological materials [2-4] have been found to show large ANE in their single crystal form. From the viewpoint of applications, it is also important to realize sizeable ANE in the polycrystalline form at a low cost. However, the systematic investigation for ANE with doping effect in polycrystalline materials is still lacking. Iron-based binary alloys Fe_3X (X = Ga, Al) were discovered with record-large ANE at room temperature [2]. In this system, the highly symmetric cubic structure ensures isotropic transport properties so the giant ANE is also expected in high-quality polycrystalline samples.

We synthesized a series of $Fe_3Ga_{1-x}Al_x$ polycrystals by arc melting and measured the evolution of the magnetic and transport properties at room temperature. Interestingly, the size of ANE in $Fe_3Ga_{1-x}Al_x$ polycrystal is still comparable with Fe_3Ga single crystal, which is also consistent with the theoretical prediction. Considering that aluminum is more low-cost and abundant than gallium, this progress would be valuable for subsequent polycrystal-based large-scale synthesis and device application.

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Effect of Collective Spin Dynamics on Anomalous Transverse Transport: Real-Time Calculation

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In recent years, the anomalous transverse conduction due to the topology in the real space has attracted much attention [1]. The real-space topology of magnetic material shows up in noncoplanar magnetic structures such as frustrated magnets and magnetic skyrmionic systems where the nontrivial spin texture arises from the spin-orbit coupling and itinerant-electron-mediated interactions [2]. Recent experiment demonstrated that such a noncoplanar spin ordering with negligible magnetization leads to sizable anomalous Hall effect which may be attributed to the emergent spin-charge coupling related to the complex spin structure [3]. The identified spin texture comprised of multiple spins allows for collective modes richer than conventional ferro- and antiferromagnets and is expected to intriguing interplay between spin and charge degrees of freedom in the induced responses as in case of the recent study of photovoltaic effect [4].

To this end, we investigate the effect of the collective spin excitations on the anomalous Hall response of noncoplanar magnet (Fig.1). We employ the real-time simulation method considering time evolution of spin and electron coupled to each other. The obtained spectrum of optical Hall response indicates that the collective spin excitations significantly influence the resonant and off-resonant contributions (Fig. 2). We analyze the results in terms of symmetry and discuss which spin modes affect the optical response of the electron system.

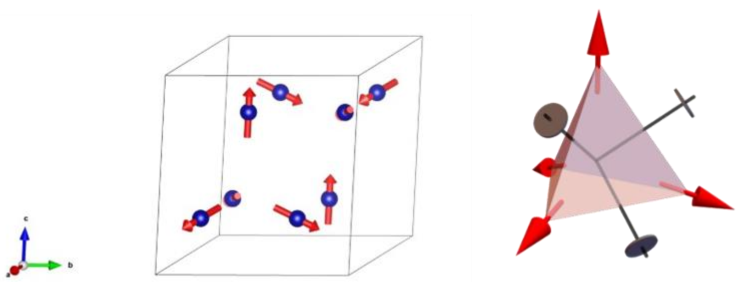

Fig. 1: All-in-all-out spin texture on triangular lattice.[5]

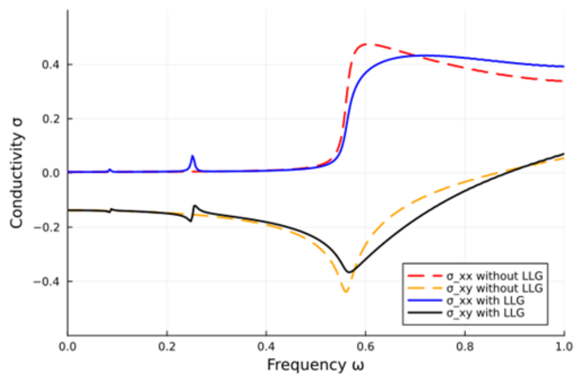

Fig. 2: Optical Hall conductivity of noncoplanar magnets with (dashed line) and without including the collective-mode effect.

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Unconventional non-Hermitian superfluid phase transition induced by the interplay between exceptional manifolds and van Hove singularity

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Recently, ultracold atoms provided a practical platform for quantum simulation. Notably, much attention has been drawn to the dynamics of the non-Hermitian (NH) Hamiltonian which is derived from extracting the conditional dynamics of open systems. In particular, NH BCS theory has been proposed [1] and many studies have been conducted so far to explore unconventional NH fermionic superfluid phase transition associated with exceptional manifolds. While the increasing importance of investigating how exceptional manifolds change conventional condensed matter physics, a unified understanding of their impact on NH many-body phenomena has not been obtained yet.

In the poster session, we discuss the effects of exceptional manifolds on quantum many-body physics through studying the NH Hubbard model on a honeycomb lattice [2]. Remarkably, we show the emergence of an unconventional NH many-body phase diagram, where the dissipation-induced superfluid (DS) phase is anomalously enlarged when ELs pass through van Hove singularity, giving rise to the cusp with the double-humped behavior. Furthermore, we show the DS state appears with infinitesimal dissipation at the critical point. This result reveals that exceptional manifolds can dominate the unconventional NH phase transitions and exotic quantum phenomena in open quantum systems.

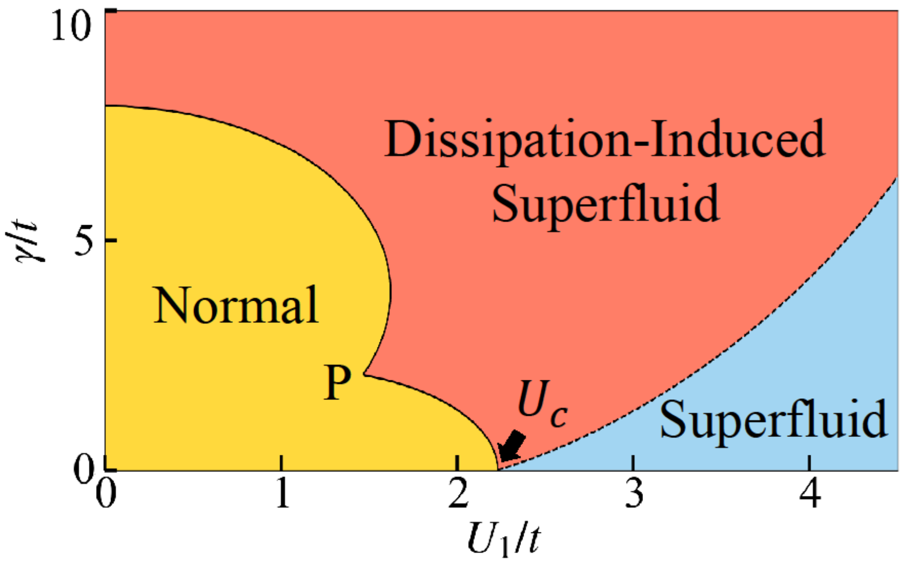

Figure 1. Phase diagram of the attractive Hubbard model with a complex-valued interaction.

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Effect of alkali halide insertion on magnetic anisotropy at the Fe/MgO interface

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Perpendicular magnetic anisotropy (PMA) has attracted attention for magnetic tunnel junctions owing to its high thermal stability and integration density. Recently, Nozaki *et al*. reported that ultrathin LiF insertion enhances the interfacial PMA at the Fe/MgO interface while maintaining the tunnel magnetoresistance [1, 2]. Motivated by these findings, we have investigated the effect of inserting various alkali halide layers at the Fe/MgO interface and studied the influence of electronegativity, spin-orbit interaction, and lattice matching on the PMA energy [3, 4].

We fabricated epitaxial Fe/alkali halide (LiF, NaCl, CsI, or NaF)/MgO multilayers by molecular beam epitaxy [Fig. 1(a)]. The surface crystallinity was examined by reflection high energy electron diffraction, and the magnetic property was characterized by polar magneto-optical Kerr effect measurement. The effect of alkali halide insertion on interfacial PMA is shown in Fig. 1(b). We find that the LiF layer insertion up to 0.4 nm and the NaF layer insertion up to 0.1 nm enhance the interfacial PMA energy, but thicker LiF and NaF insertion weaken it. Both the CsI and NaCl insertion weaken the interfacial PMA energy monotonically with CsI or NaCl thickness. Our results highlight the importance of Fe-F orbital hybridization for PMA enhancement.

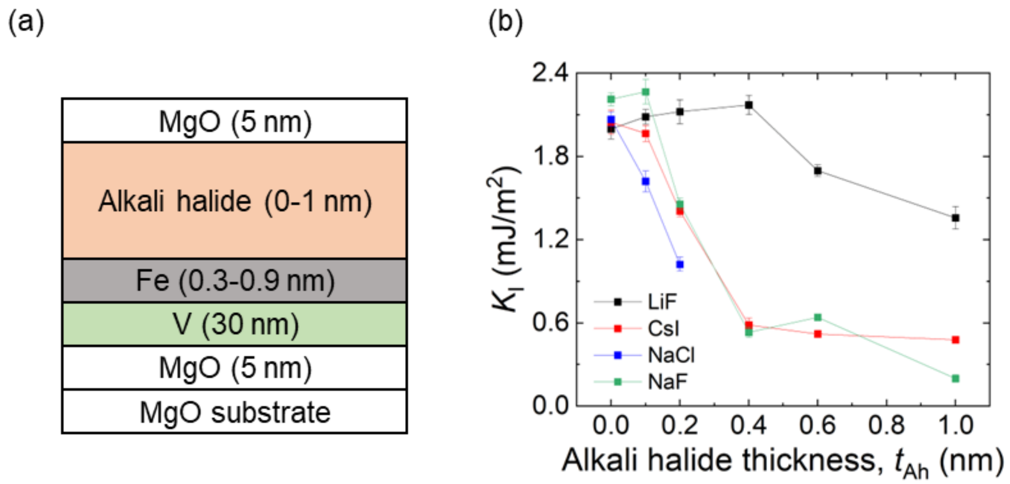

FIG 1. (a) Schematic sample structure. (b) Interfacial perpendicular magnetic anisotropy energy (K_I), for LiF, CsI, NaCl, and NaF sample

References

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Hongchao Li

Abstract: Yang and Lee investigated phase transitions in terms of zeros of partition functions, namely, Yang-Lee zeros [C. N. Yang and T. D. Lee, Phys. Rev. 87, 404 (1952); T. D. Lee and C. N. Yang, Phys. Rev. 87, 410 (1952)]. We show that the essential singularity in the superconducting gap is directly related to the number of roots of the partition function of a BCS superconductor. Those zeros are found to be distributed on a semicircle in the complex plane of the interaction strength due to the Fermi-surface instability. A renormalization-group analysis shows that the semicircle theorem holds for a generic quantum many-body system with a marginal coupling, in sharp contrast with the Lee-Yang circle theorem for the Ising spin system. This indicates that the geometry of Yang-Lee zeros is directly connected to the Fermi-surface instability. Furthermore, we unveil the nonunitary criticality in BCS superconductivity that emerges at each individual Yang-Lee zero due to exceptional points and presents a universality class distinct from that of the conventional Yang-Lee edge singularity.

Magnetic damping of epitaxial Fe/Pt multilayer characterized by time-resolved magneto-optical Kerr effect

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Magnetization damping enhancement is of great importance in both theoretical research and applications such as magnetic storage. Mizukami *et al.* reported the damping as a function of ferromagnet thickness with different nonmagnetic metals and showed that Pt has significant damping compared to other metals [1]. Recently, Barati *et al.* calculated the Gilbert damping of Co/nonmagnetic metal bilayers [2] while Azzawi *et al.* reported the Pt thickness dependence using 10nm Co [3]. For opposite fabrication sequence, Swindells et al. reported the difference between Pt/Co and Co/Pt bilayers [4]. In our research, we investigate both ultrathin ferromagnet and nonmagnetic metals thickness and sequence dependence to study the intrinsic and extrinsic damping in Fe/Pt multilayer.

We use molecular beam epitaxial to fabricate V/Fe/Pt/MgO and V/Pt/Fe/MgO thin-films. The crystallization is checked by reflection high-energy electron diffraction and the damping is measured using time-resolved magneto-optical Kerr effect. We found that the relaxation time of the free induction decay decreases as Pt thickness increases and reaches minimum at around Pt 1nm. The relaxation time of V/Fe/Pt/MgO is shorter than V/Pt/Fe/MgO, which means that the fabrication sequence will also affect the damping.

(a) (b)

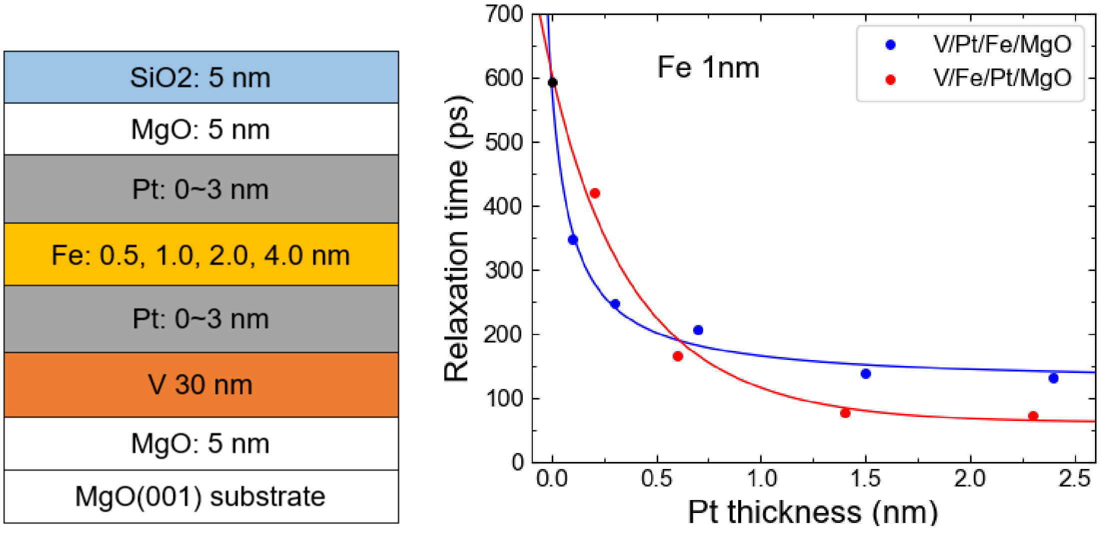

Fig.1 (a) Schematic of the sample. (b) Relaxation time dependence on Pt thickness of V/Pt/Fe/MgO and V/Fe/Pt/MgO sample.

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Aspects of critical phenomena with boundary and defect:

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Abstract (up to 200 words)

Critical phenomena are one of the long-standing subjects in theoretical physics. While they are described by conformal field theory [1], when it comes to realistic setups, we must include the effects of extended objects, which we call ***defects***, such as impurities, and the boundaries of the container of the experimental systems. We focus on a simple but significant statistical model called the critical O(N) vector model and explore its aspects in the presence of a defect. We take two different but complementary approaches, relying on the standard diagrammatic calculations combined with renormalization group analysis and the axiomatic approach that postulates three mild assumptions encompassing conformal symmetry of the system at criticality.
We demonstrate that both approaches agree well, and in particular, the analyticity of correlation functions plays a critical role in resolving the spectrum of composite operators within the axiomatic framework.

This presentation is based on [2,3], which deals with the critical O(N) model, but we here present the case of the critical Ising model (N=1) as an illustration.

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Title: Uniqueness of the non-equilibrium steady state in open quantum many-body systems

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Abstract (up to 200 words)

We consider open quantum systems described by the Gorini–Kossakowski–Sudarshan–Lindblad (GKSL) equation [1, 2]. In the presence of dissipation, quantum systems relax to a non-equilibrium steady state (NESS), and the degeneracy of NESS is a fundamental property of open quantum systems. From a practical standpoint, it is important that the uniqueness of the NESS is guaranteed in advance. For example, when calculating NESS using variational methods, it is usually assumed that the NESS is unique.

In this poster, we present a simple proof of a sufficient condition for the uniqueness of the steady states [3]. In contrast to previous studies, we focus on finite-dimensional systems, which makes the proof much more concise. We also show that our criteria are also applicable to open quantum systems with strong symmetry [4].

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Title:
Time-dependent Gutzwiller simulation of Floquet topological superconductivity

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Abstract (up to 200 words)
Periodically driven systems provide a novel route to control the topology of quantum materials. In particular, Floquet theory allows an effective band description of periodically-driven systems through the Floquet Hamiltonian. Along this direction, it was theoretically predicted that d-wave cuprate superconductors irradiated with circularly-polarized light (CPL) exhibit Floquet topological superconductivity purely from the many-body effect by employing the high frequency expansion (HFE) and deriving Floquet t–J model [1]. Here, we study the time evolution of d-wave superconductors irradiated with CPL [2]. We observe the development of the idxy-wave pairing amplitude along with the original dx2−y2-wave order upon gradual increasing of the field amplitude, owing to the three-site term with broken time-reversal symmetry (as shown in Figure). We further numerically construct the Floquet Hamiltonian for the steady state, with which we identify the system as the fully-gapped d+id-wave superconducting phase with a nonzero Chern number. We explore the low-frequency regime where the HFE breaks down, and find that the topological gap of an experimentally-accessible size can be achieved at much lower laser intensities.

References
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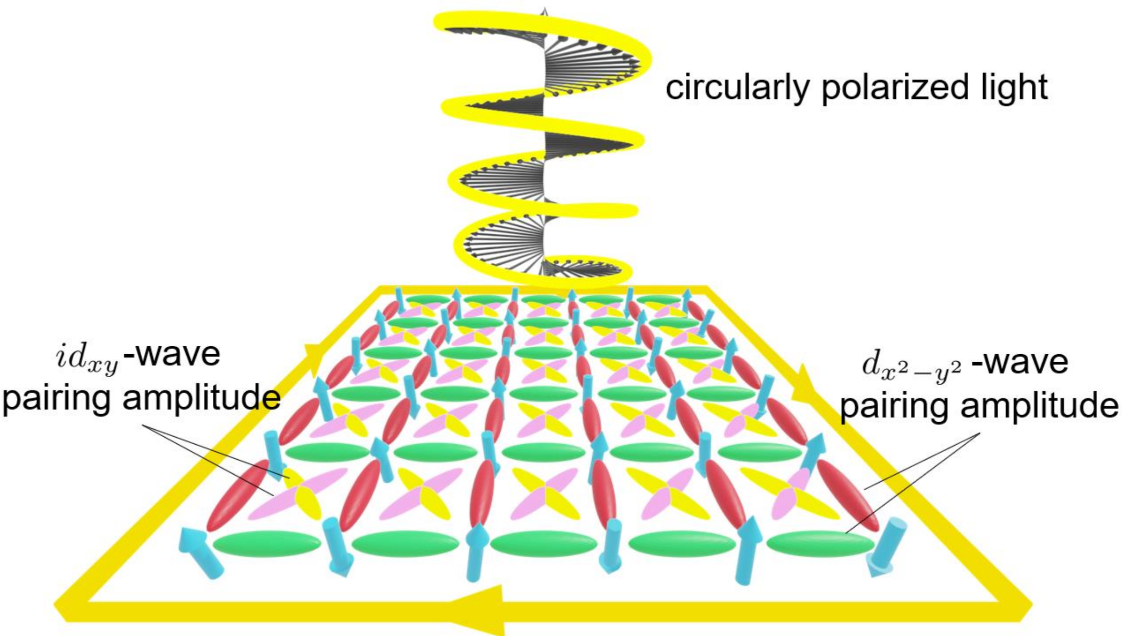

Title: Formation and evolution of galaxies in the early Universe by 3D hydrodynamics simulation

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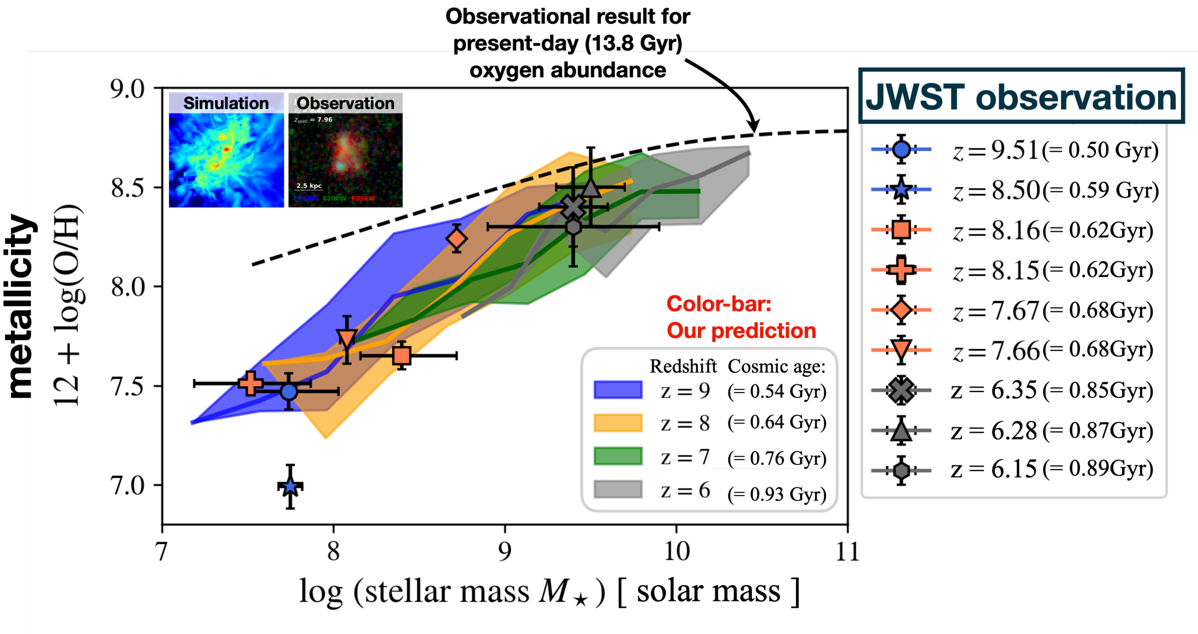
Abstract (up to 200 words)
The observation of the most distant galaxies had been one of the most cutting-edge research topics in astrophysics. In particular, James Webb Space Telescope (JWST), operational since 2022, has unveiled galaxies existing just 0.5 billion years after the BigBang, evidenced by the the detection of oxygen emission lines. In this study, we perform three-dimensional hydrodynamical simulation and follow formation and evolution of early galaxies within the first billion years after the BigBang. In order to compare simulated galaxies and observed ones, we develop a physical model of radiation field and calculate spatially resolved oxygen line emission from each galaxy. We show that the early universe is dense and galaxy merger happens frequently, which leads the surrounding gas to be tidally compressed and form clumpy structure. Through the merger-induced gas compression, galaxies experience bursty star formation. The formed stars finally end in supernovae explosion and expel a significant abundance of metal (oxygen) to galaxies. Some massive galaxy samples are already metal-enriched at the cosmic age of 0.8 billion year, whose metal abundance is comparable to the present-day galaxies[1]. Our theoretical predictions of clumpy morphologies driven by galaxy-galaxy merger and subsequent chemical evolution are consistent with the latest JWST observations.

References

[1] Y. Nakazato, N. Yoshida, D. Ceverino, 2023, The Astrophysical Journal, 953, 140, https://doi.org/10.3847/1538-4357/ace25a

The Figure is attached below



The relationship between stellar mass and metallicity of galaxies at a cosmic age of 5-10 billion years (redshift z=6-9). The distribution of galaxy samples from the simulation is shown as a band. Plots are the results of JWST observation. The top-left panels show a simulated galaxies and observed galaxies with clump structures. Merger movie can be obtained from here.

Bulk photovoltaic effect in antiferromagnet: Role of collective spin dynamics

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Inspired by recent advancements in the bulk photovoltaic effect which can extend beyond the independent particle approximation (IPA), we investigate the influence of collective spin dynamics on photocurrent generation in an antiferromagnetic system [1]. The photovoltaic effect in magnets has gained much attention due to its distinct features, such as the large photocurrent response inherent to the injection current mechanism and its tunability by manipulating the spin textures [2]. In such spin systems, the effect of spin dynamics is yet to be explored.

We employ a unified framework for real-time simulations of conduction electrons and localized spin moments. In the linear and photocurrent conductivity spectra, we observe peaks below the bandgap regime, attributed to the resonant contributions of collective modes, alongside broadband modifications resulting from off-resonant spin dynamics. Notably, we reveal that the emergence of spin dynamics allows various types of photocurrents, which are absent in the IPA framework. In terms of the tunability of the photocurrent, we show that we can tune the feedback strength from spin dynamics by modulating the amplitude of the external field. Here, we emphasize the importance of energy scale proximity between electronic and spin degrees of freedom in enabling efficient feedback between them.

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Title: Possible rattling and anharmonicity enhanced superconductivity in Sc_6MTe_2 (M= Fe, Co, Ni)

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Motivated by the recent discovery of superconductivity in Sc_6MTe_2 (M= 3d, 4d, 5d elements) [1], we investigate the role of electron-phonon coupling in Sc_6MTe_2 (M=Fe, Co, Ni) based on density functional perturbation theory and self-consistent phonon theory. Our predicted transition temperatures, importantly, reproduce the chemical trend. We attribute superconductivity to the electronegativity difference between Sc and M, which suppresses the magnetism of Fe, Co, and Ni, possibly influencing the spin fluctuations in Sc, avoiding the suppression of the superconductivity. In the M = Fe and Co cases, we observe rattling phonon modes contributing to strong electron-phonon coupling. For M = Fe, imaginary phonon modes indicative of anharmonicity are detected. The renormalized soft phonon bands lead to a prominent plateau in the Eliashberg spectral function, enhancing superconductivity. Our research suggests a strategy for designing phonon-mediated superconductors using d-elements, integrating non-superconducting and magnetic components. This study further emphasizes the critical roles of rattling modes and anharmonicity in modulating electron-phonon interactions and, consequently, superconductivity.

References

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Theory of the Inverse Edelstein Effect using Boltzmann Equation

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Abstract

In two-dimensional electron systems with Rashba spin-orbit coupling, a spin-to-charge conversion phenomenon called the inverse Edelstein effect occurs. This effect has been experimentally studied in various materials such as Ag/Bi [1], surface states of topological insulators [2], and semiconductors [3]. These studies examine the conversion from spin currents induced by spin pumping to currents. To date, there have been few theoretical studies based on microscopic descriptions of this phenomenon using spin pumping.

In our study [4], we construct a theory of the inverse Edelstein effect with spin pumping in a junction system (Fig. 1) of a ferromagnetic insulator (FI) and a two-dimensional electron gas (2DEG) with Rashba and Dresselhaus spin-orbit couplings using the Boltzmann equation [5]. In this study [4], the theory is constructed using a microscopic Hamiltonians. We clarify the dependence of the current produced by this effect on the magnetization orientation in the ferromagnetic insulator, on the frequency of the microwave irradiated from outside, and on the ratio of the sizes of the Rashba and Dresselhaus spin-orbit couplings. In this presentation, we will report on these results.

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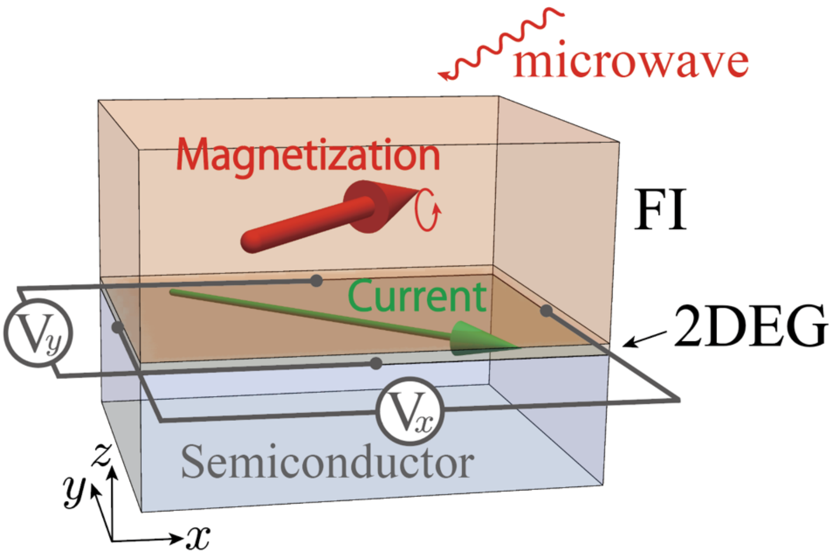

Fig. 1 Setup of our study

Title: Anomalous crystal shapes induced by topological phases protected by crystal symmetries

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Abstract
It is now well-studied how chemical bondings determine crystal shapes via dependence of surface energies on surface orientations. One can expect that topological surface states of topological materials may affect surface energies and crystal facets in an unconventional way. Here we show that the surface energy of glide-symmetric topological crystalline insulators (TCI) depends on the surface orientation in a singular way via the parity of the Miller index (Fig. 1) [1]. This singular surface energy of the TCI affects equilibrium crystal shapes, resulting in the emergence of unique crystal facets of the TCI [1]. In addition, we show that when a topological insulator transforms into a second-order topological insulator by adding a magnetic field, the crystal shape changes in a peculiar way [2].

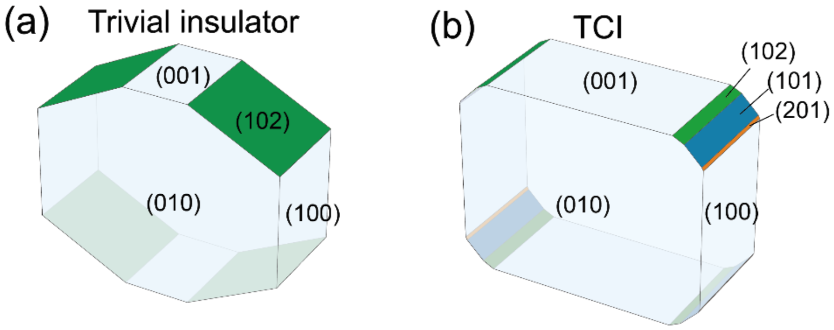

Fig. 1. Equilibrium crystal shapes of (a) trivial insulator and (b) TCI.

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Colossal negative magnetoresistance in field-induced Weyl semimetal of magnetic half-Heusler compound

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The discovery of topological insulators and semimetals triggered enormous interest in exploring emergent electromagnetic responses in solids. Particular attention has been focused on ternary half-Heusler compounds, whose electronic structure bears analogy to the topological zinc-blende compounds while also including magnetic rare-earth ions coupled to conduction electrons [1]. However, most of the research in this system has been in band-inverted zero-gap semiconductors such as GdPtBi [2], which still does not fully exhaust the large potential of this material class. Here, we report a less-studied member of half-Heusler compounds, HoAuSn, which we show is a trivial semimetal or narrow-gap semiconductor at zero magnetic field but undergoes a field-induced transition to a Weyl semimetal, with a negative magnetoresistance exceeding four orders of magnitude at low temperatures. The combined study of Shubnikov-de Haas oscillations and first-principles calculation suggests that the exchange field from Ho 4*f* moments reconstructs the band structure to induce Weyl points which play a key role in the strong suppression of large-angle carrier scattering. Our findings demonstrate the unique mechanism of colossal negative magnetoresistance and provide pathways towards realizing topological electronic states in a large class of magnetic half-Heusler compounds.

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DOI: 10.1038/s41467-02341982-4

Electronic phase control of potassium-intercalated layered MoS_2 devices

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Though MoS_2 has been examined heavily for its properties as a relatively easily used and exfoliated transition metal dichalcogenide with promising electronic properties as a semiconductor, it has more recently been studied as a 2D superconductor, for instance in heterostructures involving proximity induced superconductivity. [1] One of the most promising means for inducing 2D superconductivity is the construction of an electronic double-layer transistor (EDLT). [2] In this approach, an electron accumulation region is formed in the topmost layer, and a dome-like superconducting region can be seen when compiling temperature to carrier density phase diagram [3]. Intercalation of alkali metals or hydrogen into the van der Waals gap of the layered 2D materials has also been attracting increased interest as a means of quantum phase control. For instance, it has been shown to cause room temperature ferromagnetism in Li intercalated Fe_3GeTe_2 [4] and BCS-BEC crossover in ZrNCl [5].

As for the intercalation of alkali metals into MoS_2, although existence of the superconducting phase is known for many years, the electronic phase diagram has not been explored. Powder diffraction experiments have shown evidence of structural phase change from 2H to 1T and 1T' phases, from intercalation of a polycrystalline sample, with different superconducting critical temperatures at each phase. [6] In this study, we have performed an ionic gating experiment to understand the superconducting phase diagram of potassium intercalated MoS_2.

By precisely controlling the gating processes, we discovered multiple emergent electronic phases. One is the low carrier density state that exhibits a metal-insulator transition at approximately 80 K, which appears to be a charge density wave (CDW) state. When the carrier density is increased, we found two metallic states: one showing superconductivity at Tc = 5.5 K, and the other a highly metallic state with no apparent superconducting transition down to 2K. Based on this, we are constructing a carrier density phase diagram based on Hall-effect mobility measurements. At high levels of intercalation-induced carrier density, an irreversible transition to an unknown phase has been found using Raman spectroscopy.

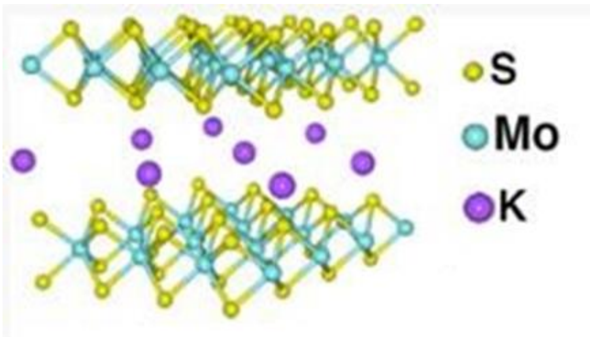

Fig. 1 Crystal structure of K intercalated MoS_2.

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Title: Decay spectroscopy and delayed-neutron measurements of neutron-rich nuclei from Os to Po at RIBF

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Abstract (up to 200 words)
The neutron-rich N ~ 126 region is important to r-process calculation around the third abundance peak and study of shell evolution across N = 126 shell closure. However, only limited information about their nuclear properties is available. Experimental measurements of nuclear properties of more exotic nuclei are essential to verify various theoretical models [1,2].

We will present recent progress in the BRIKEN experiment [3] at RIBF, RIKEN Nishina Center. Particle identification of more than 40 isotopes from Os to Po was confirmed by the BigRIPS separator and the silicon dE telescope. For the first time at RIBF, half-lives and beta-delayed neutron-emission probabilities (P_n) of N ~ 126 exotic isotopes were measured by the WAS3ABi β-counting system [4] and the ^{3}He proportional counters [5]. We expect half-lives of 46 isotopes, including 21 measured for the first time. New isomers were observed by conversion electron-γ coincidences using WAS3ABi and high-purity germanium (HPGe) clover detectors. The analysis methods used and selected preliminary results will be discussed.

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Spin dynamics in easy-plane triangular antiferromagnet $CsFeCl_3$ under pressures near the quantum critical point

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Abstract
We performed inelastic neutron scattering experiment under pressures in an easy-plane triangular antiferromagnet $CsFeCl_3$. Our investigation focused on examining the magnetic properties near the quantum critical point (QCP). Notably, we observed the observation of a magnetic Bragg Peak near the QCP, substantiating magnetic long-range order at low temperatures. While the well-defined magnetic excitation spectrum was approximately reproduced by the Extended Spin-Wave Theory (ESWT) [1], the presence of broadened excitations unveils the existence of exotic spin dynamics within $CsFeCl_3$.

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Valley-Selective Phonon-Magnon Scattering in Magnetoelastic Superlattices

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Abstract

Phonons and magnons are engineered by periodic potential landscapes in phononic [1] and magnonic crystals [2], and their combined studies may enable valley phonon transport tunable by the magnetic field [3]. Through nonreciprocal surface acoustic wave transmission, we demonstrate valley-selective phonon-magnon scattering in magnetoelastic superlattices. The lattice symmetry and the out-of-plane magnetization component control the sign of nonreciprocity. The phonons in the valleys play a crucial role in generating nonreciprocal transmission by inducing circularly polarized strains that couple with the magnons. The transmission spectra show a nonreciprocity peak near a transmission gap, matching the phononic band structure. Our approach provides a way to apply valley phonon in the bulk transport regime. It demonstrates the periodically modulated magnon-phonon coupling as a new tool for controlling the valley phonon transport [4].

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Construction of symmetry-adapted Closest Wannier models using multipole basis

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Recently, T. Ozaki has developed a non-iterative method for constructing the closest Wannier functions for a given set of atomic orbitals [1]. In this presentation, we will show the method for the symmetrization of the closest Wannier models and its applications.

In the closest Wannier formalism, by introducing the smoothly varying window function for the projection of the atomic orbitals onto the Kohn-Sham orbitals, disentanglement of bands is achieved without any iterative calculations. However, no symmetry constraint is applied in this procedure, leading to unexpected symmetry breaking. We have recently developed a method for the symmetrization of the closest Wannier models, which is achieved by expressing the Hamiltonian as the linear combination of the symmetry-adapted multipole bases (SAMBs) [2] belonging to the fully symmetric irreducible representation. In this formalism, the linear coefficients of the SAMBs are automatically determined by the symmetrization procedure.

In the presentation, we demonstrate the advantages of our method. For example, by using the method, we have constructed a symmetry-adapted Closest Wannier model of the chiral Tellurium crystal. Expressing the model in terms of the SAMBs, we have found the dominant components in both the local and itinerant terms corresponding to the electric toroidal quadrupole, G_u.

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Title: On-chip strong coupling between spin waves and surface acoustic waves

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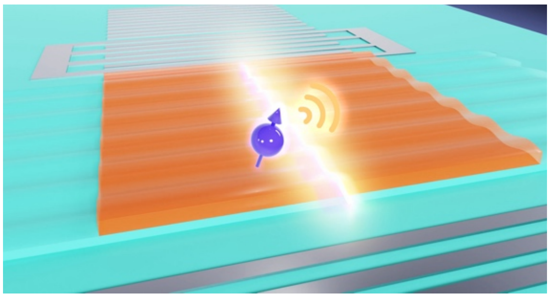
Hybridized states are distinctive of the strong coupling regime, wherein the coupling strength exceeds the relaxation rates of each coupled state. Under this condition, the coupled system demonstrates coherent energy transfer [1]. Numerous studies reported the achievement of strong magnon–phonon coupling [2–5]. However, a notable challenge arises from the pronounced dependence of the phonon wavelength on the dimensionality of the active magnetic layer within the structure [6]. This dependence restricts the independent control of the phonon wavelength and the size of the magnet, impeding the potential to amplify the coupling strength by increasing the volume of the magnet. To address this challenge, we implemented an on-chip surface acoustic wave (SAW) resonator [7] featuring a thin ferromagnetic film. This configuration allows for systematically tuning the size of the magnet while keeping the phonon wavelength consistent and enhances the shear strain of SAWs [8] which strongly couples to magnons [5]. Here we present the experimental observation of strong coupling between magnons and SAW phonons by analyzing dispersion anticrossings. As expected, we detect a monotonic increase in the coupling strength by expanding the ferromagnetic film thickness. Our work substantially advances fundamental research and develops devices based on magnon–phonon hybrid quasiparticles.



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Title: Classification of Lifshitz invariant in multiband superconductors and its application to Leggett modes

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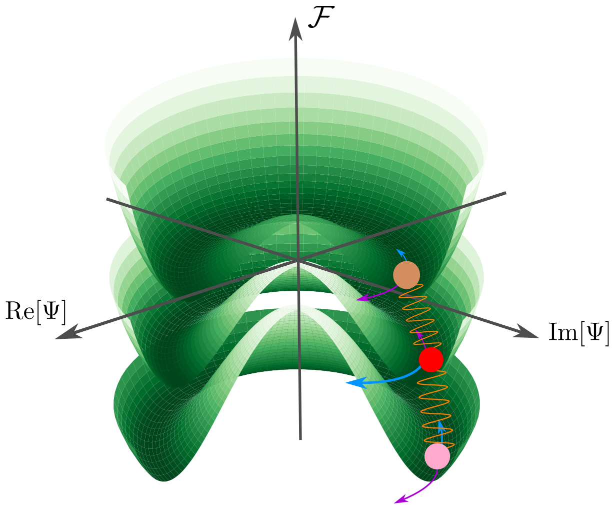
Abstract (up to 200 words)
Leggett mode is one of the collective modes originating from the phase difference between the order parameters of a multiband superconductor. Previously, it has been pointed out that the Leggett mode can be optically excited in the linear response regime, as demonstrated in a one-dimensional model for multiband superconductors [1].
However, it has not been known which crystallographic point group, particularly in two-dimensional materials, shows the Leggett mode in the linear response regime. Here we identify the linear coupling term in the Ginzburg-Landau free energy as the so-called Lifshitz invariant, which has one spatial derivative and is antisymmetric under the order parameter exchange. We classify all pairs of irreducible representations of order parameters in the crystallographic point groups that allow for the existence of the Lifshitz invariant. Using the classification, we can judge whether or not each material can show the Leggett mode in the linear response regime. We also show that the Kagome superconducting materials [2] are good candidates for observing the Leggett mode. To demonstrate this, we constructed a Kagome superconducting model with the Lifshitz invariant and calculated the linear optical conductivity [3].



A schematic picture of the free energy of a three-band-superconductor.

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Observation of domain wall in chiral antiferromagnet

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Abstract (up to 200 words)
Magnetic domain wall in chiral antiferromagnet is an important factor in developing fast magnetic memory. The fast speed of the domain wall driven by the current guarantees the perpendicular magnetic memory to move fast, but the domain wall structure, the physics background, has yet to be revealed. Here, we observed the domain wall between perpendicular magnetization of cluster magnetic octupole in Mn3Sn[1,2]. Magnetic domains with over hundreds nm scale are observed using nanoscale scanning diamond magnetometry[3]. Reconstructed magnetization is the most consistent with perpendicular polarization in all axes, including the tilted. The domain wall dominated by exchange interaction, not grain boundary, tells us the physical properties and the domain wall chirality. Detailed observation of the domain wall powerfully assists in developing materials and devices. Simultaneous revealing of the physical background contributes to understanding the non-trivial domain and spin structure.

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Multi-step topological transitions among meron and skyrmion crystals in a centrosymmetric magnet

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Topological swirling spin textures, such as skyrmions and merons, have recently attracted much attention as a unique building block for high-density magnetic information devices. The controlled transformation among different types of such quasi-particles is an important challenge, while it was previously achieved only in a few non-centrosymmetric systems characterized by Dzyaloshinskii-Moriya interaction[1].

Here, we report an experimental discovery of multi-step topological transitions among a variety of meron and skyrmion crystal states in a centrosymmetric magnet $GdRu_2Ge_2$[2]. By performing the detailed magnetic structure analysis based on resonant X-ray and neutron scattering experiments as well as electron transport measurements, we have found that this compound hosts periodic lattice of elliptic skyrmions, meron/anti-meron pairs, and circular skyrmions as a function of external magnetic field (Figure 1). Such an intricate manner of topological magnetic transitions is well reproduced by a theoretical model considering the competition between Ruderman-Kittel-Kasuya-Yosida interactions at inequivalent wave vectors. The present findings demonstrate that even a simple centrosymmetric magnet with competing interactions can be a promising material platform to realize a richer variety of nanometric magnetic quasi-particles with distinctive symmetry and topology, whose stability may be tunable by various external stimuli.

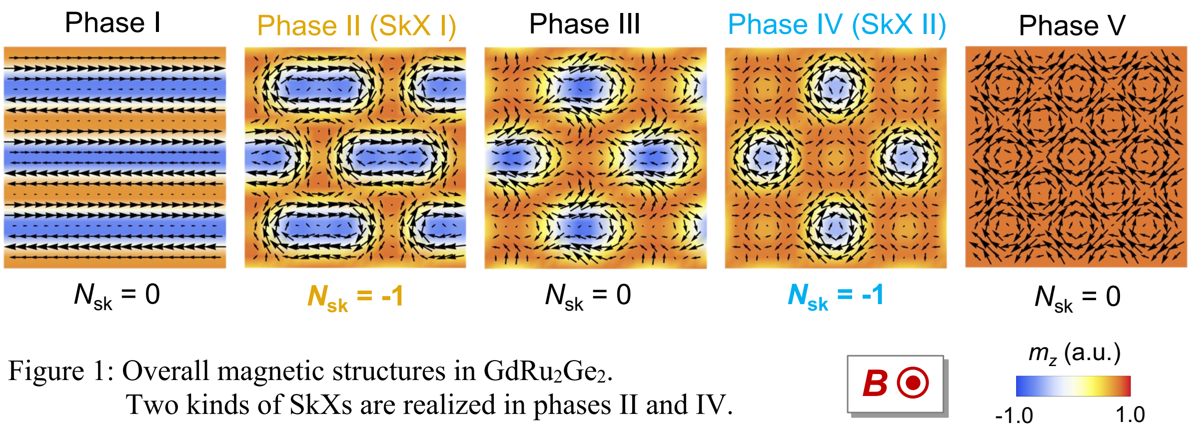

Figure 1: Overall magnetic structures in $GdRu_2Ge_2$.
Two kinds of SkXs are realized in phases II and IV.

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Resonant surface acoustic wave absorption in YIG

You Ba[1]*, Jorge Puebla[1], Kei Yamamoto[1, 2], Yunyoung Hwang[1, 3], Liyang Liao[3], Yoshichika Otani[1, 3]
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Abstract

Magnetoelastic interaction is a fundamental property of magnetostrictive material. One important effect is the magnetic resonance driven by surface acoustic waves (SAW), which causes nonreciprocal SAW absorption in magnet films [1, 2, 3]. Particularly, nonreciprocity is the key feature of rectification devices such as circulators and isolators. Ferrimagnet insulator Yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) attracts much interest due to its relatively low magnetic damping and long relaxation time [4, 5], which has great potential in microwave devices. However, the investigation of SAW driven magnetic resonance in YIG is limited by its low compatibility of YIG and SAW devices. In this work, we demonstrate resonant surface acoustic wave absorption in an on-chip YIG/SAW device fabricated by FIB technique. We present two SAW absorption features with different symmetries about propagation wavevector, which indicates a unique unidirectional SAW propagation for a board range of magnetic field directions. The large nonreciprocity in SAW propagation direction in YIG offers a promising opportunity for high-efficient rf signal processing technologies.

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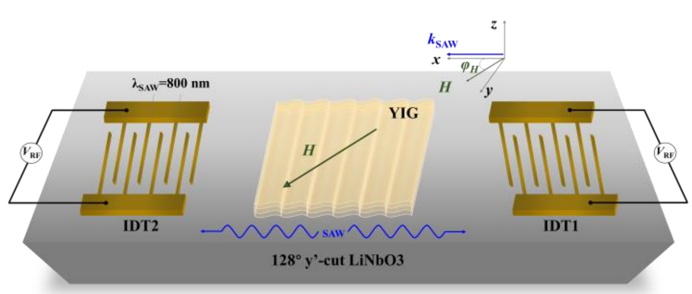

Ideal Spin-Orbit-Free Dirac Semimetal RE_8CoX_3 (RE = rare earth elements, X = Al, Ga, or In)

Manabu Sato[1]*, Juba Bouaziz[2], Shuntaro Sumita[1,3], Shingo Kobayashi[3], Ikuma Tateishi[3], Stefan Blügel[2], Akira Furusaki[3], and Motoaki Hirayama[1,3]
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Abstract
Topological semimetals are a fascinating group of materials with degeneracies between valence and conduction bands that exhibit intriguing electronic properties in the bulk and at the surface [1]. Most of the typical topological semimetals such as the Weyl and nodal-line semimetal phases have been found in real materials both in systems with negligible spin-orbit coupling (spinless systems) as well as in systems with strong spin-orbit coupling (spinful systems). However, no material realization of spinless Dirac semimetals has been discovered, in which the valence and conduction bands touch at a fourfold degenerate (without including spin degeneracy) point.

In this study, we show from first-principles calculations that spin-orbit-free materials in the RE_8CoX_3 (RE = rare earth elements, X = Al, Ga, or In) group are ideal spinless Dirac semimetals whose Fermi surfaces consist only of fourfold degenerate points. Furthermore, we investigate various topological phase transitions exhibited by the Dirac semimetal phase, which is located at phase boundaries, using first-principles calculations and effective model analysis. Lattice distortion or elemental substitutions change the system into characteristic topological semimetallic phases including linked-nodal-line and ferromagnetic Weyl semimetals.

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Cr-doping effects on the magneto-thermoelectric properties of the antiferromagnetic Weyl semimetal Mn_3Sn thin film

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In recent years, antiferromagnetic materials exhibiting large anomalous Hall and Nernst effects have been discovered despite their vanishingly small magnetization [1,2]. These substances are garnering attention as promising candidates for novel spintronic devices due to their ultrafast dynamics and negligibly small demagnetizing field. One of the typical examples is the antiferromagnetic Weyl semimetal Mn_3Sn, which is known to show large anomalous Nernst effect [3] as well as anomalous Hall effect [4] originating from Weyl points, and intensive research is being conducted for the development of devices, including non-volatile memories and magnetically robust heat flux sensors [1,5]. Recently, studies on the control of transport properties of Mn_3Sn by Fermi level tuning have also attracted much attention, and the doping effects of 3d electrons in the anomalous Hall effect have been studied [6]. On the other hand, the contribution to the anomalous Nernst effect, a probe sensitive to Berry curvature near the Fermi level, remains unexplored. In this study, we focused on Cr-doped Mn_3Sn to assess its magneto-thermoelectric responses and measured the magneto-thermoelectric properties of Mn_3Sn films with varying Cr compositions.

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Magnetic imaging by the anomalous Nernst effect using atomic force microscopy:

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Mn_3Sn has recently achieved wide attention since it exhibits anomalous Hall and Nernst effects (ANE) despite being an antiferromagnet. This can be explained by its non-collinear antiferromagnetic spinorder [1]. Mn_3Sn is a promising candidate for data storage or thermopile devices for efficient energy-harvesting. Here, we show a high-resolution magnetic imaging method which does not rely on any net magnetization and is therefore applicable on any material exhibiting the ANE. The technique is based on atomic force microscopy (AFM) and the ANE. By heating up the sample with an external heater a local vertical temperature gradient, ∇T_z, is induced by the AFM-tip contact (see Figure below). Due to the magnetization dependence of the ANE, given by

$$\boldsymbol{E}_{\mathrm{ANE}} = S_{\mathrm{ANE}} \cdot (\boldsymbol{m} \times \nabla T),$$

the magnetization of the sample can be mapped accurately. In fact, we achieved an impressive sub-100 nm spatial resolution on a Weyl ferromagnet (Co_2MnGa) [2]. Furthermore, we could show magnetic contrast in Permalloy [3] and Mn_3Sn. By simulating the induced temperature gradient, we were able to estimate the local ANE of the measured material. With this poster we want to present our results on Co_2MnGa and Mn_3Sn.

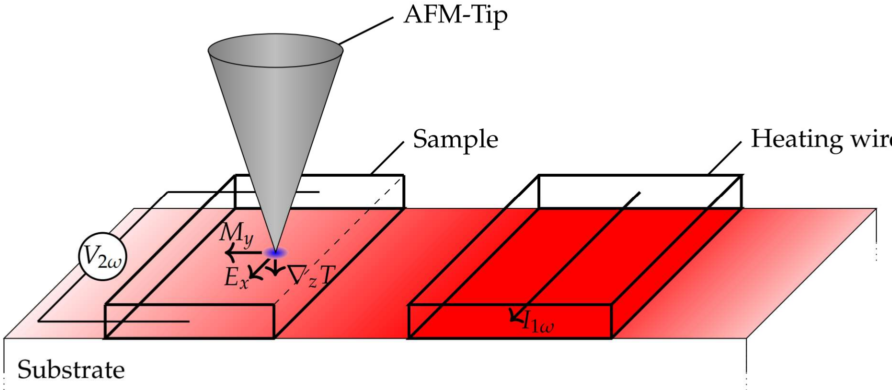

Figure: Schematics of the magnetic imaging technique. The temperature of the sample is raised by a parallel heating wire. By tip-contact on the sample a vertical temperature gradient is induced which creates the measurable ANE.

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First-principles derivation of classical spin models based on the spin cluster expansion

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Abstract (up to 200 words)
The *ab initio* construction of effective spin models for real materials is a longstanding problem. In particular, higher-order terms than the bilinear interactions are difficult to estimate directly with a conventional method, namely the local force method. By combining the spin cluster expansion[1] and the disordered local moment method (SCE-DLM scheme)[2], it is possible to expand a classical spin system's energy with arbitrary interactions and calculate its parameters from the first-principles calculation. We calculated the biquadratic interaction, which plays a crucial role in stabilizing non-coplanar spin textures for anti-ferromagnets[3,4]. Though the scheme was originally developed under the KKR-formalism, we implemented the scheme using the Wannier orbitals from the DFT with the plane wave basis. In the presentation, we will discuss the results obtained by applying the SCE-DLM scheme to 3d transition metals, which are typical magnetic materials, and compare the results with those obtained by the conventional method.

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Flux-periodic supercurrent oscillations in GaAs/InAs/Al core/shell/halfshell nanowire Josephson junctions

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Mesoscopic nanowire Josephson junctions have been proposed as a potential building block for topological systems. The state-of-the-art realization is based on the combination of a semiconductor with strong spin-orbit interaction such as InAs or InSb with an epitaxially grown superconducting shell. However, one of the main challenges is the creation of separate spin branches in the state spectrum ("helical gap") due to the strong in-plane field that is required to induce a sufficient Zeeman splitting.

To overcome this, several other approaches have been proposed that try to limit the challenges during the actual experiment by exploting more complex device layouts. One of them is based on the so-called Little-Parks effect, whose most famous signature is the formation of supercurrent "lobes" separated by dissipative transport.

Even though signatures of this effect have already been observed in nanowires fully surrounded by a superconducting shell, many questions regarding the actual formation of the hybridized states and the influence of the system dimensions still need to be addressed. Here, we use GaAs/InAs/Al core/shell/halfshell nanowires due to the strong localization of the transport within the narrow band gap semiconductor as a testbed to get more insight into this effect and to study the observed flux-periodic oscillations.

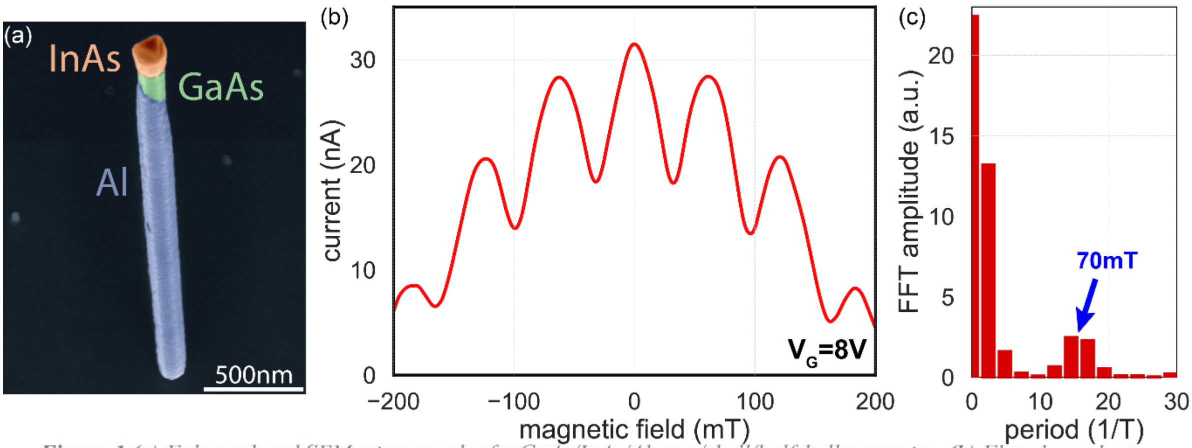

*Figure 1 **(a)** False-colored SEM micrograph of a GaAs/InAs/Al core/shell/halfshell nanowire. **(b)** Flux-dependent supercurrent oscillations induced by an in-plane magnetic field oriented along the nanowire axis. **(c)** FFT spectrum of the oscillations), revealing a pronounced and well-defined h/2e period for an effective radius located within the InAs shell.*

Title: Precipitable Water Vapor Measurement using GNSS Data in the Atacama Desert for Millimeter and Submillimeter Astronomical Observations

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Abstract (up to 200 words)
The precipitable water vapor (PWV) strongly affects the quality of data obtained from millimeter- and submillimeter-wave astronomical observations [1], such as those for cosmic microwave background (CMB) measurements. In this presentation, I will introduce the PWV measurement method using Global Navigation Satellite System (GNSS).
Compared to other PWV measurement methods, GNSS instruments are robust in bad weather conditions, have sufficient time resolution, and are less expensive. By demonstrating PWV measurements with good accuracy using GNSS instruments in the Atacama Desert, which hosts several CMB experiments [2-6], I will show that GNSS instruments are valuable tools for PWV measurements for observing site evaluation and data analysis for ground-based telescopes [7].

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Hollow Lattice Tensor Gauge Theories with Bosonic Matter

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Higher rank gauge theories are generalizations of electromagnetism where, in addition to charge conservation, there is also conservation of higher rank multipoles such as the total dipole moment among other conservation laws. In this work we study the four dimensional lattice A tensor gauge theory coupled to bosonic matter which has second rank tensor electric and magnetic fields and charge conservation on individual planes. Analytical predictions were obtained for the pure gauge case (no matter) where charge excitations are quadrupolar. For strong coupling, we retrieve a volume law where the quadrupole potential grows quadratically in the distance between charges. For weak coupling we find an area law and a linear quadrupolar potential. No phase transition was found between these regimes due to instanton proliferation. With the inclusion of matter fields with charge p=2 a distinct phase arises. We dubbed it the Higgs Phase in analogy with the rank-one U(1). At infinite gauge coupling the theory reduces to the (3+1)D XY-plaquette model.

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Nonlocally Detected Diffusive Orbital Current Generated via Orbital Edelstein Effect

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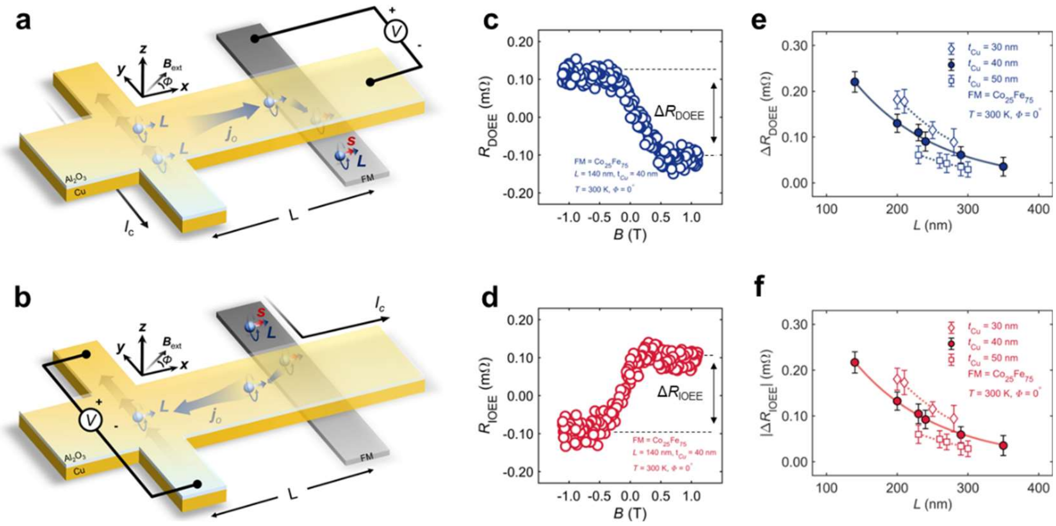
Abstract

The recently emerging field in spintronics focuses on the electron orbital angular momentum (OAM) which could similarly function like the electron spin. The nonequilibrium OAM accumulation was recently found to be generated via the interfacial orbital Edelstein effect (OEE) [1,2] and the bulk orbital Hall effect (OHE) [3]. Importantly, these charge to orbital conversions require no spin-orbit interaction. In this study, we provide robust evidence of both direct and inverse OEE in lateral transport structures, comprising orbital accumulation generator/detector Al_2O_3/Cu interfaces and detector/injector ferromagnetic nanowires. Through systematical studies of separation distance and Cu thickness dependences, we reveal that the conversion satisfies the Onsager reciprocity relation and an orbital diffusion length exceeds 110 nm, indicating the presence of a lateral orbital transport channel at the Al_2O_3/Cu interface. Our experiments lay the groundwork for future fine manipulation of OAM and establish a foundational understanding for the practical applications of spintronics.



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Non-negative Matrix Factorization Analysis for Angle-Resolved Photoemission Spectra of Graphene

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Angle-resolved photoemission spectroscopy (ARPES) has been used as a useful tool in the investigation for the direct observation of the electronic states in momentum space. In recent years, as the performance of light sources and equipment has improved, the volume of obtained data through the measurement has rapidly increased. Machine learning has been applied as a solution to increment of the data. In this study, non-negative matrix factorization (NMF) was applied to the ARPES dataset of graphene grown on SiC substrates. The dataset consists of spectra measured for graphene near the Dirac cone with the synchrotron radiation at 400 different positions on the substrate. Each spectra reflects the local electronic structure of measured region. The experimentally obtained spectra were decomposed into several features and well reproduced by the NMF. The basis and activation vectors obtained by NMF reflect changes in the spectral shape due to deviations in the number of layers and grown angles. In addition, the distribution of the graphene on the substrate were visualized through a classification by activation vectors obtained by NMF. These results indicate that NMF is an effective tool for the feature detection and the analysis for the large number of ARPES spectra.

Kazutoshi Takahashi

Among group-V elemental two-dimensional materials, a heavier Bi contributes to a stronger spin-orbit coupling (SOC), resulting in a larger bandgap opening of the non-trivial phase. Interaction between the two-dimensional layer and the substrate is vital for tuning the material properties through symmetry, electronic coupling, and strain. Recently, a flat honeycomb structure of bismuthene was distinguished on Ag(111). The flat bismuthene exhibit a (2×2) superstructure with Bi atoms located at the hollow sites of Ag(111), indicating that the distance between two Bi atoms on Ag(111) is 3.34 Å, which is 108.7% of the interatomic distance in the buckled Bi(111) layer. In this work, two-dimensional band dispersion of (2×2) superstructure with Bi grown on Ag(111), which has been urged as an ultraflat hexagonal bismuthene, is investigated using angle-resolved photoemission spectroscopy (ARPES). A band dispersing to the high binding energy side with tops at the first and second $\bar{K}$ points appears on the (2×2)-Bi surface. The observed dispersion is consistent with the calculated band with p_{xy} character in ultraflat-Bi of the (2×2) structure on 3 ML Ag(111) layers.

Thermal fluctuation induced anisotropic topological Hall effect in pyrochlore-type $Eu_2Mo_2O_7$

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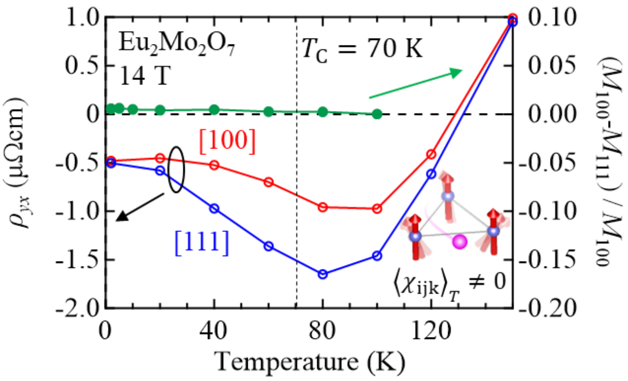
It has been demonstrated that topological spin textures play an important role in the quantum electromagnetic properties. For example, when the conduction electron is coupled to a non-coplanar spin texture, its wave function obtains the Berry phase proportional to the scalar spin chirality $\chi_{\mathrm{ijk}} = S_{\mathrm{i}} \cdot (S_{\mathrm{j}} \times S_{\mathrm{k}})$. Then the emergent Berry curvature field causes unconventional Hall effect (topological Hall effect). So far, the topological Hall effect has been mainly studied for pyrochlore $A_2B_2O_7$ compounds (A-site: *f* electron, B-site: *d* electron) [1][2]. But the coexistence of conduction electrons and localized moments makes the system complicated to explore the topological Hall effect.

Here, we report on a new topological Hall system, pyrochlore-type $Eu_2Mo_2O_7$. Because Eu^{3+} (J = 0) is non-magnetic, we can focus on the magnetic structure of Mo-4*d* electrons only. This system shows a field-anisotropic Hall effect, although all other physical properties such as resistivity or magnetization are isotropic. This anisotropy persists even above the Curie-Weiss temperature. Our comprehensive theoretical study of Heisenberg model on the pyrochlore lattice suggests that this anisotropy arises from topological Hall effect induced by thermal fluctuation. Our findings may pave the way for the topological Hall effect devices working in a broad temperature range, exceeding the magnetic transition temperature.



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Title: Theoretical studies of the electric field induced thermal Hall effect in the quantum dimer magnets XCuCl$_3$ (X = Tl, K)

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Abstract

The thermal Hall effect in magnets has attracted increasing attention in recent years as a powerful probe of elementary excitations in solids and their nontrivial band topology. In quantum dimer magnets, where neighboring two S=1/2 spins form a dimer by the strong antiferromagnetic interaction, their elementary excitations are bosonic quasiparticle triplons. However, the thermal Hall effect of triplons has yet to be detected [1] although its candidate material has been proposed theoretically [2]. For this reason, we should seek other candidate materials exhibiting the thermal Hall effect of triplons.
In this work, we theoretically propose the electric field induced thermal Hall effect of triplons in the quantum dimer magnets XCuCl$_3$ (X = Tl, K) [3], which exhibit ferroelectricity in the Bose-Einstein condensation phase of triplons. The interplay between ferroelectricity and magnetism in these materials leads to the magnetoelectric effect, i.e., an electric-field induced Dzyaloshinskii-Moriya (DM) interaction on the same dimer. We argue that this DM interaction breaks the symmetry of the system without an electric field and gives rise to the thermal Hall effect, which can be detected in realizable external fields. We also show that the thermal Hall effect can be controlled by an electric field (Fig. 1).

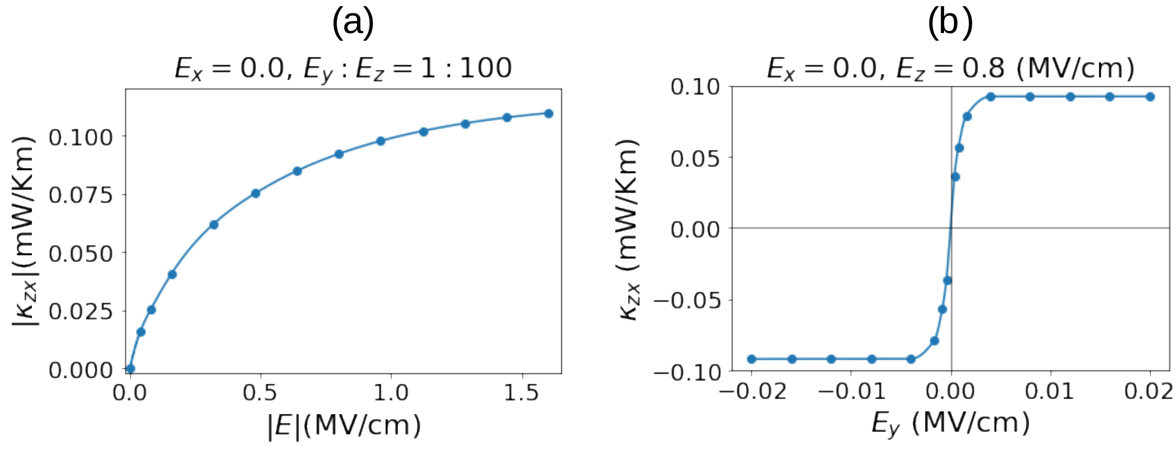

Fig. 1: Electric field dependence of the thermal Hall conductivity κ_{zx}.
(a) $|\kappa_{zx}|$ is enhanced by increasing the strength of the electric field $|\boldsymbol{E}|$.
(b) Electric field in the x-y plane changes the sign of κ_{zx}.

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Title: Fundamental Laws of Chiral Band Crossings

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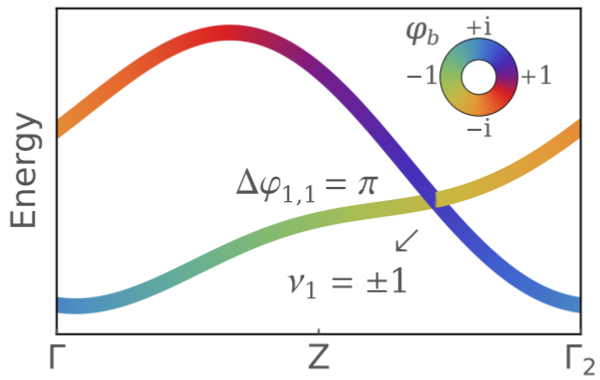
The number of surface states as well as the electric response of Weyl semimetals is determined to a large extent by the Chern number of the Weyl points, a property also referred to as their chirality. It is known [1,2] that rotation eigenvalues affect the value of the chirality.

We show that the previous works are applications of a local constraint [3], relating the Chern number with the exchange of rotation eigenvalues. We find that it holds for arbitrary combinations of symmetries as well as for chiral crossings comprising more than two bands. Using this constraint, we explain the chiralities of quadruple Weyl points, double Weyl points on two-fold rotation axes, and discuss the emergence of a Chern number 5 band within certain fourfold point crossings. Furthermore, with a global constraint, stemming from the periodicity of the Brillouin zone, we can identify space groups with enforced topological nodal planes.



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Title: No-Go Theorem from Eigenstate Thermalization Hypothesis about Work Extractability in Locally Interacting Systems

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Abstract (up to 200 words)

There exist two independent characterizations of thermal equilibrium states in quantum theory: passivity [1][2] and consistency with statistical mechanics. The former aligns with Planck's principle, representing a formulation of the second law of thermodynamics in macroscopic thermodynamics. It posits that no work can be extracted in an adiabatic cycle. The latter suggests that the thermal equilibrium state has the same expectation values of thermal observables as the microcanonical state. The hypothesis that energy eigenstates exhibit this property is termed the eigenstate thermalization hypothesis (ETH) [3][4]. While extensive research has been conducted on each of these properties, the relationship between them remains unclear. This lack of clarity becomes a crucial issue when exploring thermodynamic properties beyond equilibration in quantum many-body systems.

In this presentation, I will discuss the relationship between the maximum extractable work (ergotropy) in many-body systems and the properties of thermal equilibrium as expressed through observables. We demonstrate that ergotropy is constrained by the athermality of the initial state and the reduction of entanglement entropy resulting from quantum operations. Our findings thus indicate that the ETH prohibits work extraction from energy eigenstates during time evolution induced by local observables in 1D systems.

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Title: Development of Torsion Pendulums and Readout Optics for Gravity Gradient Observation

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Abstract
Torsion-Bar Antenna (TOBA) is a low-frequency gravity gradient detector using torsion pendulums [1]. Gravity gradient fluctuation is measured as the differential rotation of two horizontally suspended bars. The resonant frequency of torsional motion is low (~1 mHz) therefore TOBA has good design sensitivity, specifically 10^{-19} /√Hz between 0.1-10 Hz with 10 m-scale pendulums. TOBA can be used for gravitational-wave observation [1] and earthquake early warning [2]. A prototype detector Phase-III TOBA with 35 cm-scale pendulums at cryogenic temperature is under development to demonstrate noise reduction [3]. The target sensitivity is set to 10^{-15} /√Hz at 0.1 Hz. Currently we are developing cryogenic torsion pendulums made of silicon and Fabry-Pérot cavities to detect the differential rotation of pendulums.

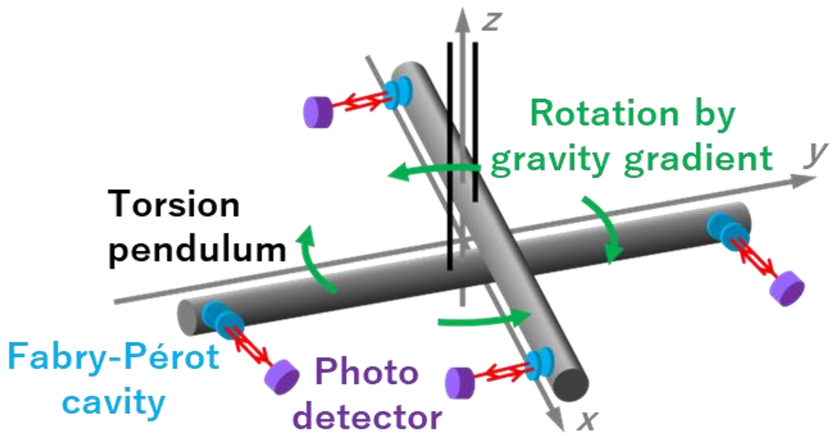

Fig 1: The schematic of torsion pendulums and Fabry-Pérot cavity

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Development of Quantum Sensing under High Pressure: Visualization of Pressure and Magnetic Field

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Abstract
NV centers in diamonds act as quantum sensors, detecting magnetic fields, pressure, and temperature with high sensitivity through optical detection magnetic resonance (ODMR) methods. The ability to quantitatively image magnetic fields make this technology promising for condensed matter physics experiments. The measurement using nanometer-sized is simple in terms of their availability and can be directly sprayed near the sample for precise measurement.
NV centers are currently being used to measure high-pressure magnetic fields in the GPa region [1]. Therefore, by adding nanodiamonds with NV centers to the sample chamber of a diamond anvil cell (DAC) for pressurization, it is expected to image the magnetic field and pressure in the vicinity of the material. This will be useful for observing changes in magnetism during high-pressure phase transitions and the Meissner effect in pressure-induced superconductivity.
In this study, imaging measurements of pressure and magnetic field were attempted using nanodiamonds scattered inside a sample chamber at 10 to 20 GPa. In addition, we analyze the measured signals considering the bias of the stress distribution and compare the results with the stress measurements obtained from the shift of the fluorescence wavelength of the ruby in the sample chamber.

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Calculation method for the coherence length at low temperatures

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Abstract

The coherence length is a macroscopic length that characterizes superconductivity and is defined by the Ginzburg-Landau (GL) theory. Recently, a method based on the GL theory has been proposed to calculate the coherence length near the transition temperature. This method utilizes the value of the gap function (Δ_q) for Cooper pairs with finite momentum (q) [1]. On the other hand, calculating the coherence length directly at low temperatures has been challenging, and it has been determined only through fitting.

In this study, we found that Δ_q is an increasing function of q at low temperatures. This is why the coherence length is calculated as the imaginary length using the conventional GL theory (Fig. 1). To overcome this problem, we extended the GL theory, developing a method for calculating the coherence length at low temperatures (Fig 1). In this poster presentation, we will discuss the details of the extended GL theory and our methodology for calculating the coherence length at low temperatures.

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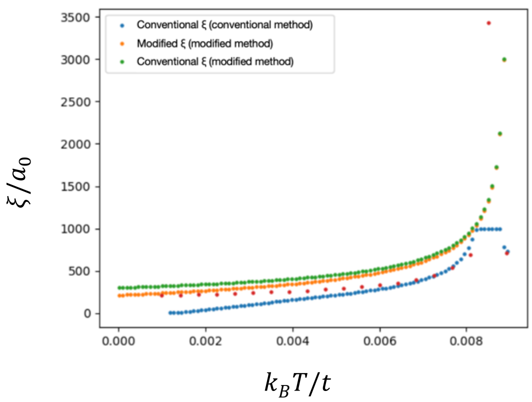

Fig. 1 Temperature dependence of the coherence length ξ calculated in a one-dimensional attractive Hubbard model. Here, t is the nearest neighbor hopping, $k_B T$ is the temperature, and a_0 is the lattice constant of the system.

Search for superconductivity in La-N-H by evolutionary algorithm, neural network potential, and density functional theory

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Lanthanum hydride (La-H) has attracted much attention as a potential candidate for room-temperature superconductivity since the discovery of the superconductivity at 260 K at pressure of 170 GPa [1,2]. The superconducting critical temperature T_c was reported to be further increased to 556 K, which has been considered to be caused by reaction of La-H with other materials [3], and the information on ternary or multinary hydrides based on La is crucial for the understanding of the “hot superconductivity”.

Assuming that La-H is reacted with hydrogen-source NH_3BH_3, we explored thermodynamically stable and superconducting phases in the La-N-H system at 20 GPa. We quickly optimized a few thousand structures created by evolutionary algorithm [4] using universal neural network potentials on Matlantis [5], extracted only a few ten structures emerging near the formation-energy convex hull, and optimized them using the density functional theory calculations. For the stable compounds obtained by repeating this process, we calculated T_c using the Allen-Dynes formula and found a new superconducting material, La_2NH_2, showing T_c of 14.4 K [6]. The T_c value is far from hot superconductivity and further studies are required to verify it. This work is supported by ENEOS Corporation.

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Energy Flow during Relaxation in an Electron–Phonon System with Multiple Modes: A Nonequilibrium Green's Function Study

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The relaxation dynamics of correlated electron systems is one of the important phenomena in nonequilibrium condensed matter physics. Although approximate methods such as the temperature model (TM) [1] and Boltzmann equation (BE) [2] have been widely used to analyze the relaxation, it remains unclear whether the relevant processes can be properly explained using them. Therefore, it is crucial to identify the necessary elements to explain the relaxation dynamics using the microscopic approach, i.e., the nonequilibrium Green's function method [3].

In this study, we introduce an extended Holstein model where electrons couple to two phonon modes, and study the relaxation dynamics using nonequilibrium dynamical mean-field theory (DMFT). To clarify the microscopic mechanism of the energy flow, we compare the full energy flow calculated with nonequilibrium DMFT and the approximated energy flow calculated with approximations employed in the TM and BE. In the weak electron-phonon coupling regime, we confirm that the mechanism of the energy flow is well explained in terms of the effective temperatures as in the TM. On the other hand, in the stronger electron-phonon coupling regime, we find that the effects beyond the TM and BE are necessary to capture the behavior of the full energy flow [4].

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Topological interface states of magnetic half-Heusler materials

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Half-Heusler materials are a well-known platform for engineering topological and other electronic properties, leveraging their compositional and structural richness. In this study, we elucidate the emergence of topological interface states in magnetic half-Heusler compounds through the iterative Green's function approach. Our primary focus centers on the rare-earth-based half-Heusler compound LuPtBi, which was experimentally reported to exhibit topological surface states. By interfacing it with the magnetic trivial half-Heusler GdNiSb, we demonstrate the persistence of topological boundary states at the interface, further accompanied by a fairly large quantum anomalous Hall gap around tens of meV. Considering the superconducting behavior in LuPtBi, we will additionally discuss the intriguing prospects of topological superconductivity within this LuPtBi-GdNiSb interface. Other candidate systems will also be introduced.

Title: Microscopically-derived quantum master equation for a boundary-driven Hubbard model and its application to nonlinear thermoelectric effect

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Abstract (up to 200 words)
Boundary-driven systems, systems coupled to two external baths at their ends, are good platforms for studying nonequilibrium states and transport phenomena. One way to describe quantum systems in contact with external degrees of freedom is to use quantum master equations in the theory of open quantum systems [1]. Quantum master equations are well understood for small open systems, such as atoms or molecules coupled to environments. However, it has been claimed that the established equations are not directly applicable to open many-body systems or transport phenomena [2].

In this study, we microscopically derive a quantum master equation for a boundary-driven fermionic Hubbard model, and numerically verify its applicability to transport phenomena [3]. We apply the derived equation to the thermoelectric effect and find a nonlinear sign-reversal behavior through numerical calculations (Fig. 1). We also give a physical interpretation of the nonlinear behavior based on the derived expression of the equation.

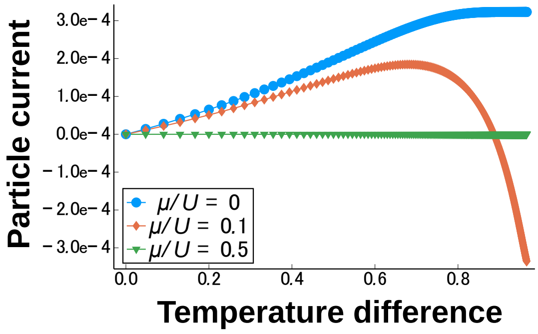

Figure 1: Dependence of steady particle currents on temperature differnece of the two baths. Here, μ and U denote the chemical potential and the on-site interaction, respectively.

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Octupole polarization switching in Mn_3Sn probed by magnetoresistance through magnetic tunnel junction with different sizes

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Antiferromagnetic spintronics has attracted attention from both the fundamental physics viewpoint and its potential for applications [1,2]. The tunnel magnetoresistance (TMR) effect in a magnetic tunnel junction (MTJ) was difficult to realize with antiferromagnets though some theoretical attempts had been made [3]. Recently, however, the TMR effect was observed with noncolinear antiferromagnets Mn_3Sn [4] and Mn_3Pt [5]. Then, the magnetic order of Mn_3Sn is characterized by the cluster magnetic octupole moments. In the Mn_3Sn-MTJ, the resistance change corresponds to the switching of the cluster magnetic octupoles [4]. The switching process of the sub-micron scale dot can be examined by the anomalous Hall effect induced by shunting current through adjacent Hall bar, or using MTJ structure. So far, the former approach has been used with different sizes of the junctions [6].

We examined how the junction size of Mn_3Sn-MTJs affects the octupole polarization switching process using several Fe/MgO/Mn_3Sn MTJ devices with different junction diameters Φ. The TMR effect was clearly observed down to Φ = 500 nm (Figure). As Φ increases, the switching field approaches a constant value, and the switching becomes more gradual. Interestingly, this can be explained by the grain structure of the polycrystalline Mn_3Sn.

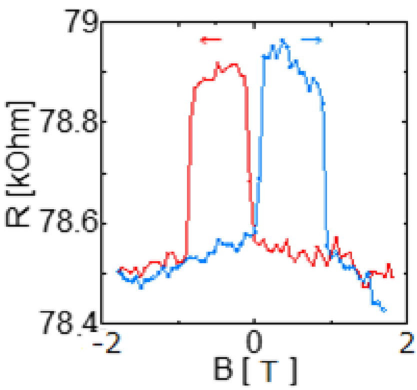

Figure TMR effect of Fe/MgO/Mn_3Sn MTJ with Φ = 500 nm at 300 K. Arrows show sweep directions of out-of-plane magnetic field.

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Dynamic control of spin-wave by electric field in rare-earth iron functional oxide thin films

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In Rare-earth Iron Garnet (RIG) thin films, both spin and dipole coexistence are expected by breaking the spatial inversion symmetry in tilted strained structure at the nanoscale [1]. Symmetry broken RIG thin films can be achieved by controlling the epitaxial strain. This study aims to facilitate electric field-controlled spin-wave propagation in symmetry broken RIG thin films. Using comb-shaped interdigital metal electrodes, we applied an in-plane electric field and investigated the electric field-controlled spin-wave propagation. We fabricated 100-120nm $Lu_3Fe_5O_{12}$ thin films on partial lattice mismatched (~-0.88%) $Ga_3Gd_5O_{12}$ substrates using the pulsed laser deposition technique. Subsequently, using photolithography and DC sputtering techniques, we fabricated a pair of Au co-planner waveguides and Pt interdigital electrodes (Fig.1(a,b)). We measured spin-wave propagation by microwave technique using a Vector Network Analyzer (Fig.1(c)). The spin-wave transmission spectra characteristics indicate a significant right shift with the application of the electric field and completely turns back after removing the field. This phenomenon may be attributed to spin–orbit coupling as well as the spin-momentum locking in the ferromagnet/heavy-metal interface originating from the Dzyaloshinskii–Moriya interaction [2]. This dynamic E-field controlled energy-efficient and heatless spin-wave device can be demonstrated as an alternative to conventional field effect switching devices.

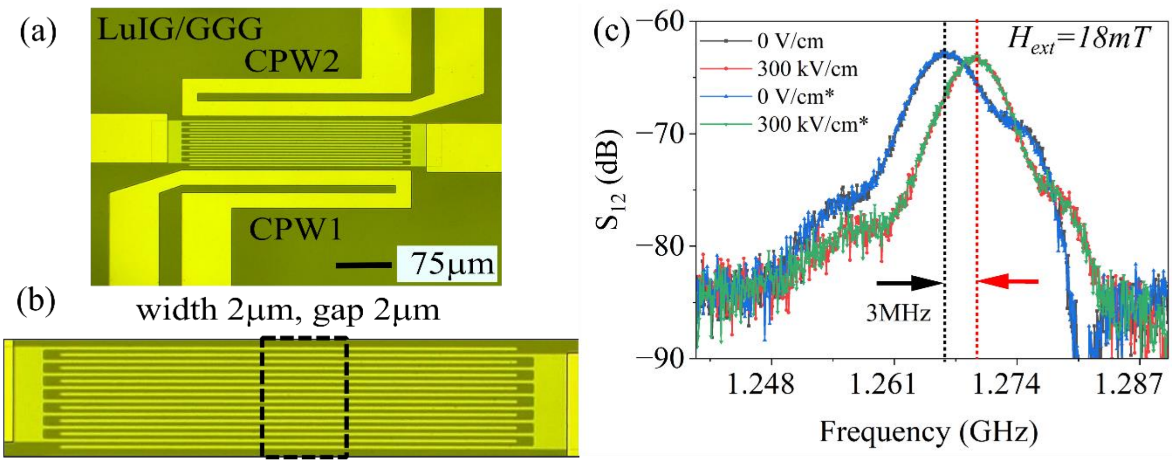

Fig.1. Optical image of (a) CPW and IDE fabricated on $Lu_3Fe_5O_{12}$ film, (b) enlarged view of IDE and (c) spin-wave transmission spectra under the influence of electric field (* indicates 2nd loop)

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Nanoscale imaging of magnetic texture dynamics by ultrafast Lorentz transmission electron microscopy

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Abstract
Ultrafast manipulation of nanoscale magnetic textures holds great promise for achieving GHz-THz operation in spintronic devices. To explore this potential, it is essential to study the dynamics of such magnetic nanotextures on ultrafast timescale [1]. Ultrafast transmission electron microscopy (UTEM), which combines pump-probe method and electron microscopy, emerges as a powerful technique due to its high spatiotemporal resolution [2]. Additionally, time-resolved Lorentz transmission electron microscopy (LTEM) measurement allows us to investigate ultrafast magnetic dynamics.

In this presentation, we introduce a recently developed ultrafast LTEM system at RIKEN and demonstrate its capability for ultrafast nanoscale imaging with nm × ns resolution. As an example, we performed UTEM measurements on pulse laser-induced magnetization dynamics in helical $Co_9Zn_9Mn_2$. Our observations revealed the demagnetization process followed by the recovery of the helical structure within the nanosecond to microsecond timescale. Furthermore, we extended UTEM to track nm × ns current-induced magnetic domain wall dynamics. By applying nanosecond pulsed current at current density below 1×10^{10} A/m^2 on ferromagnetic $(Fe_{0.63}Ni_{0.3}Pd_{0.07})_3P$, we observed domain wall dynamics in which pinning potential plays an important role. These results highlight the versatility and capability of UTEM for studying photo- and current-induced dynamics in nanoscale magnetic textures.

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Roll-to-Roll Printing of Anomalous Nernst Thermopiles for Perpendicular Heat Flux Sensing

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The anomalous Nernst effect (ANE) converts heat flux perpendicular to the plane into electricity, in sharp contrast with the Seebeck effect (SE), enabling mass production, large area, and flexibility of its devices through ordinary thin-film fabrication techniques[1,2]. Heat flux sensors, one of the most promising applications of ANE[3-5], are powerful devices for evaluating heat flow and can lead to energy savings through efficient thermal management. Moreover, the development of various topological magnets [6,7] exhibiting the giant ANE has led to practical applications of ANE-type heat flux sensors. In reality, however, SE caused by the in-plane heat flux is always superimposed on the measurement signal, making it difficult to evaluate the perpendicular heat flux.

In this study[8], we demonstrate a ANE-based flexible heat flux sensor that directly and selectively detects the perpendicular heat flux, where the Seebeck coefficients of the topological magnet Fe-Ga and electrode material in the thermopile circuit are adjusted to be nearly equal. Additionally, the SE-free sensor is fabricated by a simplified process designed for roll-to-roll sputtering systems. Our demonstration of the direct perpendicular heat flux sensing fabricated by mass-producible sputtering methods paves the way for practical applications of ANE-type flexible thermoelectric devices.

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Giant anomalous Nernst effect in the epitaxial and polycrystalline films of the Weyl ferromagnet Co_2MnGa

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Recent discoveries of topological magnets have opened up diverse spintronic applications of their large responses beyond magnetization scaling observed in conventional ferromagnets[1]. A prominent example is the anomalous Nernst effect (ANE), a transverse magneto-thermoelectric phenomenon that produces an electromotive force orthogonal to the heat flux and magnetization. Unlike the Seebeck effect generating an electromotive force parallel to the heat flux, transverse thermoelectric properties of ANE well fit in the lateral configurations of devices suitable for conventional thin-film fabrication processes[1-4]. This feature enables distinct device applications through a simplified fabrication process, reduced production cost, extensive area coverage, and enhanced flexibility[5]. In this study, we focused on the Weyl ferromagnet Co_2MnGa showing the largest ANE of −8 μV/K at room temperature in its bulk form[6]. We have fabricated epitaxial films of the Co_2MnGa on MgO substrates with the giant ANE of −5.5 μV/K originating from an atomically controllable topological band structure. Moreover, we have also worked on the preparation of polycrystalline thin films suitable for mass production, and succeeded in fabricating a film with the largest ANE of −5.4 μV/K among thin films on amorphous templates[7]. Our works lay the foundation for the future advancement of practical lateral magneto-thermoelectric devices.

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Observation of magnetization process in artificial honeycomb spin ice through tunnel magnetoresistance effect

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Artificial spin ice (ASI) exhibits emergent dynamics [1], which can be applied to potential applications such as a magnonic device [2] or physical reservoir computing [3, 4]. In the previous experiments, the ASIs' magnetization process was measured slowly by spectroscopic methods [1, 5], causing low precision of magnetization switching properties in the individual cells and their coupling. In this study, we fabricated ASIs by patterning magnetic tunnel junction (MTJ) films so that magnetization process of the individual cells can be measured precisely by magnetoresistance (MR) measurement. The MTJs had a FeB (15 nm) free layer on a CoFeB /MgO film stack, which was microfabricated into 150-nm-wide and 800-nm-long stadium shape cells arranged in honeycomb structures [6] with distances between the nearest vertexes of 1-2 μm. The ASIs consisted of 72 cells, in which 62 cells' MR curves were measured repeatedly at room temperature. The observed hysteresis loops were well reproducible, which showed large MR ratios of 130-150% and average switching fields of 230-310 Oe with standard variations of 20-40 Oe, depending on cell arrangements. The magnetostatic coupling, evaluated quantitatively from the difference of the minor MR loops measured after saturated in opposite directions, increased with decreasing the distance.

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Title: The doping-dependent evolution of superconductivity in the multilayered cuprate

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The long debate surrounding the interplay between a superconductivity and an antiferromagnetic (AF) order in the cuprate high-T_C superconductors, has clearly shown that the superconducting pair can manifest even in the presence of an AF order, which is evident from the observation of the pairing gaps in the small Fermi pocket in a multilayered cuprate [1,2]. The small Fermi pocket, which is the indication of a highly underdoped and low-disordered clean CuO_2 plane with long-lived quasiparticles provides plentiful information on the true nature of the superconductivity in cuprate high-T_C superconductors (Fig. 1b, c). To elucidate the superconductivity with an AF order, it is required to investigate the electronic structure near the quantum critical points of the AF order. In our study, we focus on the 4-layer cuprate $Ba_2Ca_3Cu_4O_8(F, O)_2$ (F0234, Fig. 1a), which may have larger carrier densities in inner CuO_2 planes yet clean. Our study employs angle-resolved photoemission spectroscopy (ARPES) to investigate the detailed electronic band structures of the F0234. By studying 4-layer samples with different doping levels, we focus on the relationship between the T_C and the superconducting gap sizes, which is related to the essential of the superconductivities of highly underdoped cuprate families.

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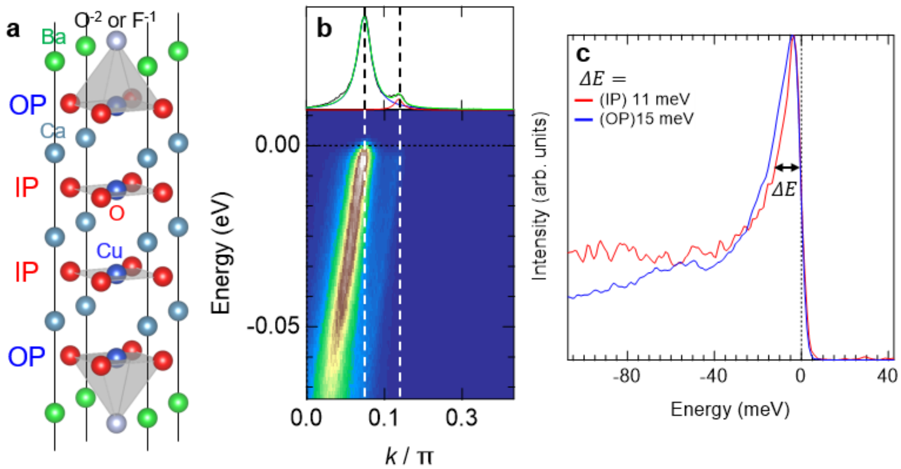

Fig. 1 **a**, The Crystal structure of $Ba_2Ca_3Cu_4O_8(F, O)_2$. **b,** ARPES spectra of F0234 at the node. **c,** The energy distribution curves taken along cuts indicated in **b.** (dashed line)

DFT Calculations on Spin-Splitting Phenomena in Altermagnetic $CaCrO_3$

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Altermagnetism has recently emerged as a new class of magnetism, having an alternating spin configuration and vanishing magnetization in real space [1]. In contrast to conventional antiferromagnets, altermagnetic materials manifest the spin splitting phenomena in the reciprocal space owing to the magnetic ordering that breaks the *PT* (parity times time-reversal) symmetry. This band splitting is guaranteed by the existence of opposite-spin sublattices connected by the crystal-rotation symmetries. Several collinear antiferromagnetic materials are identified to exhibit altermagnetism, including RuO_2 and MnTe [2].
In this talk, I will review our recent DFT study on $CaCrO_3$ as a prototypical perovskite transition-metal oxide that exhibits the altermagnetism and the sizable anomalous Hall effect [3]. Our symmetry analysis clarified that the antiferromagnetic order parameter belongs to the same irreducible representation as the ferromagnetic order parameter in the nonsymmorphic space group, allowing the nonvanishing Berry curvatures in the reciprocal space. By performing DFT calculations, we found that the Berry-curvature *"hot spots"* lie along the gapped nodal lines where spin-orbit coupling induces the spin splitting of Cr-*3d* bands near the Fermi energy and enhances the anomalous Hall effect in $CaCrO_3$.

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Title: Robust two-qubit entangling gate scheme for collision-free scalable quantum processor

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Abstract (up to 200 words)

Quantum computers are gaining more and more attention thanks to their potential applications to various fields such as biology, finance, and cryptography. Among various implementations of quantum computers, fixed-frequency transmon qubits are the most studied architecture in the sense of scalability. However, in the contemporary mainstream two-qubit (cross-resonance) gate scheme, it is imperative for the qubit parameters to fall within the "straddling regime." This imposes heavy constraints on qubit parameter design flexibility, making cross-resonance gate susceptible to qubit parameter fluctuations.

Recently, a novel two-qubit gate scheme, the coupler-assisted swap (CAS) gate, was proposed. It was numerically shown that the gate scheme can efficiently perform two-qubit gate outside of the straddling regime [1]. We have analyzed the newly proposed gate in detail and calculated the yield rate of collision-free quantum processors using our scheme.

In this presentation, we will introduce the experimental progress in the proposed two-qubit gate (CAS gate) working outside the straddling regime and numerically compare the yield rate of quantum processors of our scheme with traditional scheme (CR gate), highlighting that our scheme enables high-fidelity gate under qubit frequency fluctuations.

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Calculation of the Green function and ionization energy based on the transcorrelated method

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Abstract

The transcorrelated (TC) method [1] is a many-body wave function theory that considers the electron correlation effect through the explicitly correlated wave function using Jastrow factor. A characteristic feature of this method is a one-body calculation using the non-Hermitian effective Hamiltonian, which includes up to 3-body interaction terms. In previous studies, the TC method succeeded in calculating some important physical quantities [2-4]. In this presentation, I will introduce some theoretical progress of this method. In the TC method, the effective Hamiltonian isn't Hermitian. Hence, the variational principle cannot be applied. In the first topic, let me explain how to introduce the fundamental equations in this method. The second topic is defining the Green function for the TC method and computing its self-energy using perturbation theory. The reconsideration of the Green functions is necessary due to the non-Hermiticity of the effective Hamiltonian, similar to the introduction of equations. Finally, we apply it to the 1D half-filling Hubbard model [5] and check the results from the ionization energy calculation point of view.

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Large Photoelasticity in Topological Antiferromagnet Mn_3Sn Studied by Coherent Acoustic Phonon

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Abstract
Ultrafast control of magnetism in Weyl antiferromagnet (AFM) Mn_3Sn attracts great attention for its prospect of realizing ultrafast information processing in AFM-based spintronics [1]. In particular, the responses of the thin film to external perturbation as fast as 1 ps need to be clarified [2]. In this work, we present pump-probe spectroscopy for transient near-infrared transmission of Mn_3Sn thin films and analyze large coherent oscillation induced by the pump pulse.
We used Mn_3Sn thin films with thicknesses of 15-50 nm on SiO_2 substrate and detected the differential transmission change with pump and probe pulses at 1030 nm with 160-fs duration. A large triangle-shaped oscillation of the transmission was observed after photoexcitation, and the oscillation frequency is inversely proportional to the film thickness. Our calculation considering pulse-induced coherent acoustic phonon successfully reproduced the result and revealed an large photoelastic coefficient of Mn_3Sn in the near-infrared region. We also discuss the potential to manipulate magnetism by controllable acoustic-phonon-related strain field [3] and near-infrared optical response.

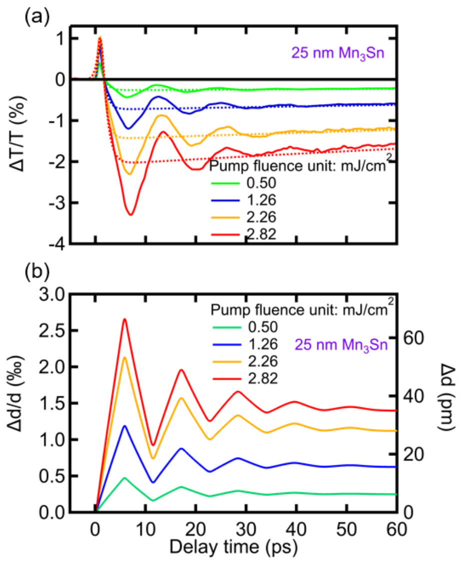

Fig.1 (a) Transient transmission of 25 nm Mn_3Sn film. The oscillation appears on the offset shown by the dashed curves. (b) Calculation of the coherent acoustic wave accompanied by thermal expansion.

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Intense photoexcitation exposes 2000-times higher-mobility carriers in correlated kagome antiferromagnet Mn_3Sn

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Abstract

Strongly-correlated kagome antiferromagnet Mn_3Sn exhibits the colossal anomalous Hall effect owing to its cluster multipole magnetic structure and the topological band structure hosting Weyl fermions near the Fermi energy. However, the strong correlation effect significantly renormalizes the band structure with quite low mobility of ~1 $cm^2\,V^{-1}\,s^{-1}$, and the correlation effect on the nontrivial band topology in this compound requires vigorous investigation. Photoexcitation of carriers may mitigate the correlation by screening the Coulomb interaction.

In this work, employing photocarrier injection, we investigate nonequilibrium carrier transport properties via time-resolved terahertz Faraday spectroscopy. Under equilibrium conditions or moderate photoexcitation, the anomalous Hall response is dominant [1,2]. By high-density photoexcitation beyond 1 mJ cm^{-2}, however, a cyclotron resonance is clearly observed, indicating the emergence of unusual carriers with higher mobility of ~2600 $cm^2\,V^{-1}\,s^{-1}$ than that in equilibrium The result can be attributed to a drastic change in the band structure resulting from the screening of the electron correlation, highlighting the significant role of many-body effects in this kagome compound in equilibrium [3]. Our work also suggests that the electromagnetic response of Weyl fermions may be prominent in the correlated kagome magnet Mn_3Sn under the extreme nonequilibrium condition.

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Systematic construction of unconventional η-pairing states in multi-body interacting systems

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Abstract
The dynamics of quantum many-body systems exhibit various exotic phenomena such as photoinduced phase transition, quantum time crystal, and quantum computation. In general Hamiltonian systems, every energy eigenstate behaves similarly to thermal states, but quantum many-body scar (QMBS) states show nonthermal behavior in a long time even in such nonintegrable systems, and are important exceptions to thermalization dynamics. We consider superconducting scar states as promising candidates for nonequilibrium superconductivity, aiming at superconductivity that can exist even in nonequilibrium states. The η-pairing state has been studied in the context of superconducting scar states in Refs. [1–3]. Here, we present a systematic model construction method in which unconventional η-pairing states appear as QMBSs using multi-body interactions, specifically doublon–electron three-body interactions as shown in Figure. Our strategy is to cancel the energy increase of the colliding Cooper pairs by the multi-body interactions. We numerically confirm the nonintegrability of the multi-body interacting model and nonthermal properties of the *d*-wave η-pairing state to prove that the unconventional η-pairing state can be regarded as a QMBS.

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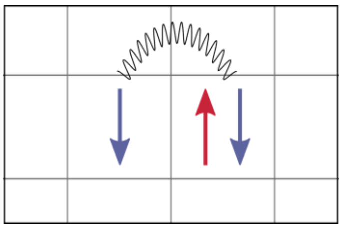

Figure: Schematic picture of doublon–electron three-body interaction

Energy-Efficient SOT-MRAMs Using Spin Hall Effect of Amorphous W-Ta-B Alloys

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Abstract

Spin current generation via spin Hall effect is a key technology to realize fast and reliable writing operations for spin-orbit-torque magnetoresistive random-access memories (SOT-MRAMs). For practical application, spin Hall material needs to satisfy several important requirements. Those are high spin Hall angle for energy-efficient writing, high thermal annealing stability for the semiconductor integration process, and compatibility with CoFeB/MgO-based magnetic tunnel junctions (MTJs). β-W is one of the promising candidate materials because of its large spin Hall angle [1], compatibility with magnetic tunnel junctions (MTJs) [2,3], and suitability for mass production. Meanwhile, its low thermal annealing stability has made it a major challenge [4]. Here, we present amorphous W-Ta-B alloys (Fig. a) as a new candidate spin Hall material [5]. Even without a long-range crystal order, W-Ta-B alloys exhibit both large effective spin Hall angles up to 40% and superior annealing stability (up to 400°C) enabling them to satisfy the above requirements. We also fabricated nanoscale three-terminal SOT-MRAM cells and demonstrated high magnetoresistance ratios up to 130% and low intrinsic switching current densities down to 4×10^6 A/cm^2 (Fig. b). These results show that amorphous spin Hall materials can provide the key essence to realizing high-performance SOT-MRAMs.

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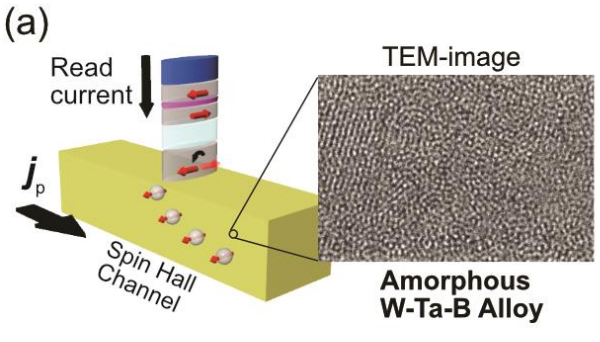

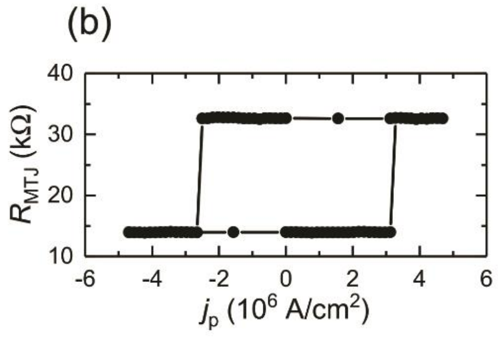

Observation of the exchange bias at polycrystalline chiral-antiferromagnet/collinear-antiferromagnet interface

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Replacing ferromagnets (FMs) in spintronics devices by antiferromagnets (AFMs) has attracted attention because of the expectation for realizing ultrafast and ultralow power devices [1,2] Recent intensive studies on AFMs with macroscopically broken time reversal symmetry has solved the difficulty controlling and detecting the antiferromagnetic order with a vanishingly small magnetization [2,3]. A chiral AFM Mn_3Sn is the most studied antiferromagnetic material possessing such a lower symmetry. The practical integration of AFMs into device architectures is becoming realistic after the recent experimental confirmation of the electrical control of the antiferromagnetic order via spin orbit torque [4] and its detection through the tunneling magnetoresistance in this material [5]. Given the development of ferromagnetic spintronics, the local manipulation of the magnetic properties by interlayer coupling such as the exchange bias effect is essential for developing antiferromagnetic spintronics. For better compatibility with existing Si-based devices, this manipulation of antiferromagnetic order should be realized in polycrystalline thin films. In this presentation, we report the exchange bias effect observed at the interface between polycrystalline Mn_3Sn and collinear AFM MnN films on an amorphous substrate.

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Title: Magneto transport properties of Ferri magnet $GdCo_2$

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Abstract (up to 200 words)

In recent years, magnetic materials exhibiting large anomalous Nernst effects have attracted much attention in the studies of thermoelectric materials [1]. The anomalous Nernst effect is a phenomenon in which a voltage difference orthogonal to both magnetization and a temperature gradient emerges, and is known to be enhanced by the sum of Berry curvature near the Fermi level [2,3]. Many existing thermoelectric devices use the Seebeck effect, but using the anomalous Nernst effect has advantages such as enabling the creation of thinner devices and reducing contact resistance[4].

From the viewpoint of application, magnetic materials with a high Curie temperature and large thermoelectromotive force Syx are required. In this study, we focused on the ferrimagnet GdCo2 as a magnetic material with the highest Curie temperature of 405 K in the RCo2 (R: rare earth) system[5].

In this talk, I will report on the anomalous Nernst effect and various physical properties measured for Ferri magnet GdCo2, which is predicted to have a large density of states near the Fermi level based on first-principles calculations. We also compare our results with predictions of physical properties based on first-principles calculations.

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Magneto-Thermoelectric Effect in Epitaxial Thin Film of Topological Nodal Plane Kagome Ferromagnet Fe_3Sn

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Recent intensive research on various kagome metallic systems has revealed abundant electronic phases such as the correlated topological states, charge density wave ordering, and superconductivity [1-3]. Among them, the Fe–Sn compounds are a well-known platform with a complex interplay of topological band structures, electronic correlations, and magnetism [4]. More recently, large transverse responses have been observed even in nano-structure Fe–Sn films due to the Berry curvature originating from the short-range ordering of the kagome lattice fragments [5].

In the kagome ferromagnet Fe_3Sn, both theoretical and experimental studies have shown the existence of a novel topological band structure, nodal plane, near the Fermi level, leading to the large transverse thermoelectric conductivity α_{yx} and anomalous Nernst effect (ANE) at room temperature [6], which is suitable for thermoelectric device applications [7]. Although thin films are essential to realize thermoelectric devices using ANE, the thermoelectric properties of Fe_3Sn films have not been clarified. Here, we have fabricated (0001)-oriented epitaxial thin films of Fe_3Sn and investigated their magnetic and magneto-transport properties. In this presentation, we will discuss the thermoelectric properties of our film based on α_{yx}, sensitive to the band structure near the Fermi energy.

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Observation of orbital Hall effect in Ru/FM nanostructures

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Recently, the Orbital Hall Effect (OHE) has been intensively explored as an alternative to the spin Hall effect (SHE). The OHE generates a transverse orbital current via the application of a charge current, represented by $\langle \boldsymbol{L} \rangle = \boldsymbol{k} \times \boldsymbol{J}$ where $\boldsymbol{J}$ is the charge current density [1]. This study aims to explore the OHE and orbital currents by electrically detecting orbital accumulation (OA) in Ruthenium nanowires; Ru is a suitable platform to study OHE due to its small spin-orbit coupling and its 5d unfilled shell. Additionally, theoretical predictions indicate a large orbital hall conductivity [2-4].

We employed lateral devices consisting of an OH material wire connected to two ferromagnetic wires (FM) that detect spin accumulation converted from the OA via spin-orbit interaction (Fig.1.a). A current flowing in the Ru wire generates the OA that diffuses into FM wires where two FM detectors can measure an electrochemical potential difference. This study provides evidence for OHE in Ru/FM transport nanostructure (Fig.1.b), Ru thickness dependence, and temperature dependence of OA signal. These experiments offer an alternative approach to studying OHE, allowing us to clarify orbital transport properties in ruthenium and other materials. This understanding holds significance for potential applications in future orbitronics.

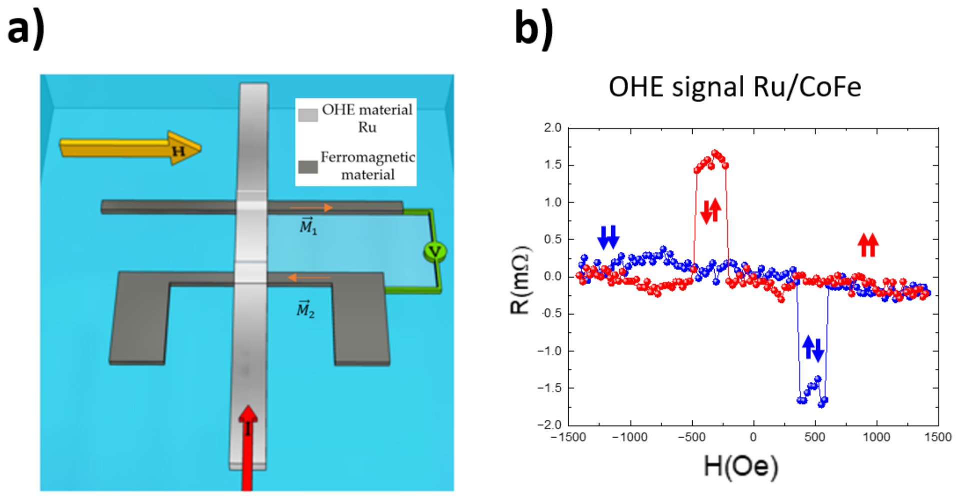

Figure 1 **a)** Schematics of the local orbital accumulation device. H is an external magnetic field, the different switching fields of these wires allow us to reach the antiparallel magnetization state and measure a voltage between them. **b)** Orbital accumulation measurement signal, the arrows illustrate the magnetization configuration of the FM detectors.

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Title: Pump-probe spectroscopy of NiFe film grown on chiral antiferromagnet Mn_3Sn

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Abstract (up to 200 words)

D0_{19}-Mn_3Sn is a typical chiral antiferromagnet (Fig 1a). It has attracted attention due to its magnetic effects, such as the anomalous Hall effect [1]. While most research on spintronics devices has utilized multilayers of Mn_3Sn and ferromagnetic metals [2], the spin dynamics in ferromagnetic metals interfaced with Mn_3Sn remain unclear. This research investigates the spin dynamics in $Mn_3Sn/Ni_{81}Fe_{19}$ bilayer using time-resolved magneto-optical Kerr effect (TR-MOKE) measurements (Fig. 1b).

A MgO(110) substrate/W (7 nm)/Mn_3Sn (20 nm)/MgO (0-3.5 nm)/$Ni_{81}Fe_{19}$ (4 nm) sample was fabricated using the molecular beam epitaxy method. The Gilbert damping constant of NiFe was evaluated from the free induction decay (Fig. 1c), obtained via TR-MOKE. An enhancement of the Gilbert damping constant was observed when the thickness of the MgO insertion layer was less than 1 nm. The mixing conductance comparison with that reported in the previous study [3] will be discussed.

This work was partly supported by JSPS KAKENHI, JST-Mirai Program, Spin-RNJ, and X-NICS.

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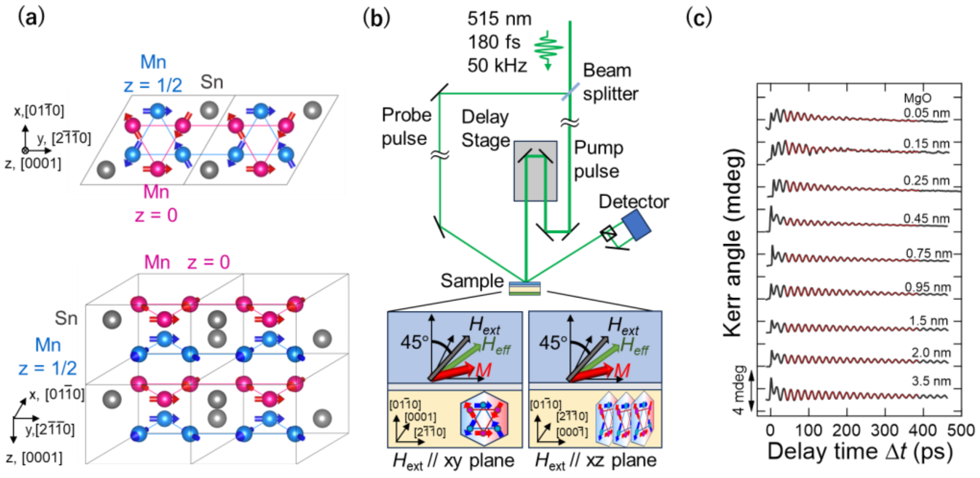

Fig. 1 (a). Spin and crystal structures of Mn_3Sn. (b) Schematic of the TR-MOKE experiment. (c) Typical measurement results.

The accuracy of the harmonic Hall measurements on spin orbit torques in W/CoFeB

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Spintronics is a field that actively utilizes the spin degree of freedom of electrons in addition to the charge degree of freedom. One of the representative phenomena of spintronics is the spin Hall effect [1,2]. Harmonic Hall measurement [3–5] is widely used to evaluate the magnitude of the spin Hall effect because it combines relatively low measurement difficulty with high measurement accuracy. On the other hand, when considering perpendicular magnetic films, it is known that the measurement does not work well for systems with specific conditions, such as W/CoFeB [6,7]. The objective of this study is to clarify the reason behind this and clarify the limitation of this technique.

We prepared W (3)/CoFeB (1) perpendicularly magnetized film by RF sputtering and fabricated it into a Hall bar by photolithography. We performed harmonic Hall measurements on the same sample in the in-plane and out-of-plane magnetization configurations. The estimated spin torque efficiency showed a significant dependence on the ratio r of the planar Hall effect to the anomalous Hall effect, and the magnetic anisotropy field H_{k}. We evaluated the impact of r and H_{k} on the harmonic Hall measurements using model calculations. In the presentation, we discuss the limitations of harmonic Hall measurements and provide guidelines for further improving the measurement accuracy.

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First-Principles Electrical Conductivity Calculations of Ag-Pd Alloy based on Wannier-CPA Method:

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Abstract

In material design, it is important to predict the properties of mixed crystals by continuously changing their compositions. For this purpose, coherent potential approximation (CPA) is a powerful tool. However, due to its formulation, DFT-based CPA has been implemented only in specific electronic-structure-calculation packages, such as those based on the KKR or TB-LMTO methods.

Recently, Wannier-function based CPA (Wannier-CPA) [1] has been developed, which is computationally efficient and can be easily combined with any DFT packages. It was confirmed that this method well reproduces magnetic properties of Fe-based transition metal alloys obtained by KKR-CPA. To apply this method for transport properties, we develop a code to calculate the electrical conductivity of substitutional alloys based on Wannier-CPA. For the analytic continuation of the response function, two numerical analytic continuation methods are employed [2]. We find that the results well reproduce previous experimental and theoretical studies [3,4].

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Theoretical study on anomalous Nernst effect enhanced at van Hove singularity in two-dimensional materials

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Abstract

The thermoelectric effect is a phenomenon where a temperature gradient generates an electric field and can effectively harness waste heat. Two primary types of thermoelectric effects exist the longitudinal (Seebeck) and the transverse (Nernst). The Seebeck effect generally yields a higher thermoelectric conductivity than the Nernst effect. On the other hand, the Nernst effect offers the advantage of simplicity and durability in thermoelectric devices.

Our research involved conducting model calculations on a kagome lattice with a chiral spin state, specifically focusing on the density of states (DOS) and subsequent thermoelectric conductivity. Notably, the DOS exhibits singularities known as van Hove singularities (VHS). Our findings demonstrated that these VHS enhanced thermoelectric conductivities, leading to the anticipation of a significant anomalous Nernst coefficient, approximately 10 μV/K at 50 K [1].

To explore a more practical system, we performed first-principles calculations on the two-dimensional ferromagnet CrGeTe3, which was observed experimentally [2]. This calculation resulted in identifying a nodal line and the computation of the DOS associated with this nodal line. It was reported that VHS of the nodal line DOS enhanced thermoelectric conductivity [3]. In our study on CrGeTe3, a large thermoelectric conductivity was obtained at the VHS of the nodal line DOS.

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Topological degeneracy and emergence of transport phenomena in antiferromagnetics

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The transport phenomena in antiferromagnetic (AFM) nowadays has much attention because of its advantages in spintronic applications such as faster spin dynamic or higher energy efficiency than in ferromagnet. The effects were well characterized through the topological aspect via Berry phase concept. Recently, it has been experimentally observed some certain AFMs belongs to the same space group *Pnma* class. They have magnetic moments of *3d* electrons on Mn atoms order in a collinear-AFM CuMnAs [1] or a zigzag-AFM NbMnP [2] at room temperature. The CuMnAs has been noted for the emergence of the spin Hall effect from Dirac nodal lines in the $k_y=0$ plane [3]. On the other hand, the NbMnP also exhibits significant Berry curvature around Fermi surfaces in the plane and has a large anomalous Hall conductivity [2]. This work aims to analyze the detailed topology degeneracy of the AFM states in CuMnAs and NbMnP, with and without SOC, to understand the origin of their significant transport phenomena.

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Dynamic Redox Reaction-Driven Electrically Tunable Magnon FET

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Spin-waves offer Joule heating-less data transmission capability and additional degree of freedoms like phase, frequency, wavelength etc. However, energy efficient control of magnon is still missing. Here, we propose a new dynamic redox reaction-based approach in an Au/PEDOT:PSS/Pt/YIG heterostructure (Fig.1(a)). Here, the SWs propagate along the surface of YIG while the switching voltage is applied across PEDOT:PSS. The propagation of Spin-waves (Fig.1(b)) for different voltage levels. Under electric field −OH from PSS dissociate to yield H+ ions, which selectively target the double bond in the PEDOT chain (Fig.1(c)), resulting in the formation of C^+ (at PEDOT) and O^- (at PSS) ions [1]. By manipulating the potential at the Pt terminal (Fig.1(d) and (e)), C^+ and O^- ions can be preferentially directed. Specifically, in Fig. 1(d), Pt acquires electrons from O^-, leading to an excess of electrons in Pt. The d-orbital filling reduces the spin-orbit interaction in the Pt layer, resulting in lower spin relaxation [2], reduced damping, and increased magnetization in the Pt/YIG bilayer. Conversely, applying an opposite polarity initiates a reverse chain of effects. The occurrence of the redox reaction is evidenced by the cyclic voltammetry measurement displayed in Fig.1(f).

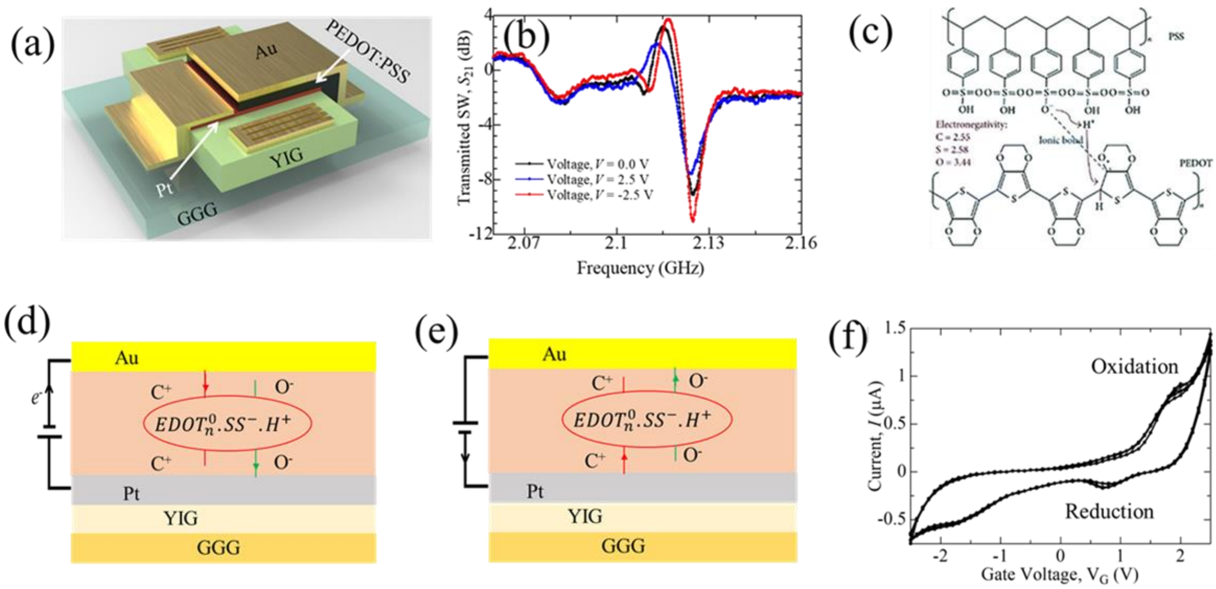

Figure 1. (a) Schematic diagram and (b) Tunable S_{21} (c) PEDOT:PSS polarization process. Pt (d) reduction and (e) oxidation process (f) Cyclic-voltametric measurement of PEDOT:PSS.

Acknowledgement
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Anti-Poiseuille flow by spin Hall effect

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Hydrodynamics emerges in electric current when the electron-electron interaction dominates over the other momentum-nonconserving scatterings. The hydrodynamic equation that describes the electric current includes viscosity, extending beyond the Ohmic transport[1]. In this paper, we show an exotic class of viscous electron fluid, arising in electron systems exhibiting the spin Hall effect (spin Hall systems), where the orbital and spin motions are coupled. Such a viscous electron fluid emerges even in non-interacting electron systems, and the current density exhibits a minimum in the center of a flow and a maximum at the edges, i.e., an anti-Poiseuille flow[2] realizing. We also find that the spin accumulation by the spin Hall effect is connected to the electric current vorticity in two-dimensional spin Hall systems. We propose a novel guiding principle to manipulate topological magnetic textures from the hydrodynamic viewpoint. By solving the hydrodynamic equation in a two-dimensional spin Hall system with a cavity and employing micromagnetic simulations for an attached chiral magnetic insulator, we demonstrate that spin accumulation near the cavity's boundary leads to the creation of a magnetic skyrmion. Our research illuminates new aspects of electron hydrodynamics and spintronics, contributing significant insights to the fields.

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Surface and bulk magnetic structure of Mn_3Sn epitaxial thin films studied by x-ray magnetic circular dichroism

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Abstract (up to 200 words)

The chiral antiferromagnet Mn_3Sn has attracted considerable attention due to its robust ferromagnetic responses, despite the absence of net magnetization [1]. Recent development of Mn_3Sn epitaxial thin films has led to the demonstration of full electrical switching of antiferromagnetic order [2]. For further advancement in this field, it is necessary to clarify whether chiral antiferromagnetic order is consistently realized across the entire film, encompassing surface and bulk regions.

In this study, we fabricated an epitaxial Mn_3Sn thin film consisting of MgO (110) substrate/W (7 nm)/Mn_3Sn (30 nm)/MgO (3 nm) using the molecular beam epitaxy method. We performed x-ray magnetic circular dichroism (XMCD) measurements on using both total electron-yield (TEY) and partial fluorescence-yield (PFY) modes, with probing depths typically of 5 nm and 100 nm, respectively. This difference in probing depth can clarify whether there are variations in magnetic and electronic structures between the surface and bulk regions. The XMCD experiments were performed at the beamline BL25SU of SPring-8. The obtained TEY XMCD spectra were consistent with those reported in a previous study [3]. Notably, PFY XMCD spectra closely resemble TEY spectra, indicating the realization of non-collinear chiral antiferromagnetic order throughout the Mn_3Sn layer.

This work was partly supported by JSPS KAKENHI, JST-Mirai Program, Spin-RNJ, and X-NICS.

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Title: Electrical control of skyrmionic lattice in centrosymmetric non-frustrated insulating magnets

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Abstract

The integration of electric control over magnetism via the magnetoelectric effect presents significant potential for the advancement of multiferroic materials in the development of future technological devices [1]. A particularly interesting magnetic configuration is the skyrmionic lattice, which stands out both for its fundamental significance and its application potential. Commonly, the stabilization of skyrmions involves Dzyaloshinskii-Moriya (DM) interactions or magnetic frustrations with anisotropy. Especially, in centrosymmetric magnets, the emergence of a skyrmionic phase is predominantly observed in systems characterized by magnetic frustration with anisotropy [2].

In this talk, we explore a new mechanism: the stabilization of skyrmions in non-frustrated centrosymmetric magnets through external stimuli. Our approach utilizes a Ginzburg-Landau type theoretical framework to provide a comprehensive analysis of this phenomenon. A prediction of our model extends beyond the skyrmionic phase, highlighting the capacity of minimal electric fields to induce transition of spiral magnetic structures, such as transition between cycloidal and proper-screw type spirals. As an illustrative example, we explore several quasi-2D centrosymmetric magnetic insulator, discussing its potential as a candidate material for demonstrating the discussed effects. This work not only advances our understanding of skyrmionic stabilization mechanisms but also opens avenues for electrically controlled magnetic structures in practical applications.

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Title: Supercurrent Distribution on Superconducting Quasicrystals

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Abstract (up to 200 words)

Quasicrystal is a solid that shows sharp Bragg peaks although it does not have periodicity in its structure [1,2]. Therefore, it often exhibits unique electronic states. Recently, the first bulk superconductivity was reported in Al-Mg-Zn quasicrystal [3] while it breaks the prerequisite of the Bardeen-Cooper-Schrieffer (BCS) theory such as the well-defined momentum space. On the other hand, some theoretical works pointed out some exotic superconducting states, particularly the existence of Cooper pairs with finite center-of-mass momentum in the weak coupling region even without an external magnetic field [4,5].

Motivated by such works, we studied the spatial distributions of the local supercurrent induced by a uniform vector potential [6,7]. The attractive Hubbard model was numerically studied within the Bogoliubov-de Gennes mean field theory. We will show that non-uniform supercurrent distributions can be realized under inhomogeneous superconducting states in quasicrystals. Furthermore, it is clarified that the paramagnetic components of the supercurrents can flow in a direction perpendicular to the applied vector potential and are finite even at zero temperature. Such phenomena can also be expected in the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state [8,9], however, we note that our results make experimental access much easier because a proper adjustment of the magnetic field is unnecessary in quasicrystals.

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Title: Shift current responses of a two-dimensional system approaching the Weyl semimetal phase

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Abstract (up to 200 words)
In our recent studies, we revealed that the electric polarization of a two-dimensional system has a finite jump when the system changes across a two-dimensional Weyl semimetal phase. We derived a concise formula to describe this jump of polarization using a newly introduced quantity “Weyl dipole” [1,2]. This jump can be understood to have originated from the U(1)-gauge redundancy of quantum states and the multivaluedness of the electric polarization.

Motivated by these results, we investigate the shift current responses of two-dimensional systems in a limit where the system approaches the two-dimensional Weyl semimetal phase. The shift current is a kind of nonlinear optical response and intimately related with the electric polarization [3]. Thus, we can expect a singular behavior of the shift current when the system approaches a two-dimensional Weyl semimetal phase. We numerically and analytically find that the shift current conductivity behaves inversely proportional to the light frequency and diverges in a two-dimensional Weyl semimetal limit.

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Title: Current-induced orbital polarization at Cu/Oxide interface

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Abstract (up to 200 words)

Current-induced orbital polarization and orbital transport open an alternative spin manipulation mechanism [1,2]. The current-induced orbital polarization could introduce a novel functionality to Spintronic devices, particularly due to its broad material range, which is attributed to its independence from spin-orbit coupling (SOC).

In this study, we focused on current-induced orbital polarization at Cu/Oxide interfaces [3]. The selected oxides were MgO, Al_2O_3, SiO_2, and TiO_2, with cations having similar atomic numbers to avoid unintended impacts from the SOC. The efficiency of the current-induced orbital polarization was measured using torque efficiency in ferromagnet/Cu/Oxide films. As a result, we found that the Cu/SiO_2 interface is the most efficient system in terms of orbital polarization. The efficiency decreases in order of the Cu/TiO_2, Cu/MgO, and Cu/Al_2O_3 interfaces. Based on the torque efficiency results and material characterizations, we conclude that promoting the interaction between *p*-orbital of oxygen atoms and *d*-orbital of Cu atoms is a key factor in advancing orbital polarization in these material systems. Further discussion will be provided during the conference.

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Title: Wannier-Stark ladders emerging in the single-particle excitation spectra of the Hubbard model

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Abstract (up to 200 words)

Phenomena induced by dc electric fields in strongly correlated electron systems, such as Mott breakdown and field-induced magnetism, have been widely discussed both experimentally and theoretically. Recently, intense terahertz light pulses generated from synchrotron radiation have attracted particular attention as a method for observing these phenomena [1] since the energy of terahertz light is quite small compared to the characteristic energy of Mott insulators and it can be regarded as a low-frequency limit, i.e., almost a dc electric field. By using this terahertz light as the pump light and examining the dynamical response from the probe light, the properties of strongly correlated materials in a dc electric field can be clarified [2].

In this study, we investigate single-particle excitation spectra of the one-dimensional Hubbard model under a dc electric field, employing an infinite matrix-product-state representation. In the Hubbard model, the lower and upper Hubbard bands appear in the excitation spectra due to the opening of the Mott gap, and the spectra split into multiple peaks by the field. This result can be understood as the appearance of a Wannier-Stark ladder [3] due to a tilted potential.

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Microscopic Mechanism of Magnetic Stability in Monolayer Transition-Metal Dihalides

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Boosted by the experimental discovery of intrinsic ferromagnetism (FM) in atomically thin layers of CrI_3 and $Cr_2Ge_2Te_6$, two-dimensional (2D) magnets have recently received increasing attention [1,2]. On the other hand, 2D antiferromagnetic (AFM) materials, such as $NiPS_3$ and $MnPS_3$, have been reported very recently as candidate materials appealing for antiferromagnetic spintronics applications [3]. Typically, 2D triangular lattice causes magnetic frustration and often results in non-collinear magnetic orderings such as 120° AFM configuration. In this study, we performed first-principles calculations to investigate the magnetism in a series of monolayer MCl_2 (M=V, Mn, and Ni) [4, 5]. These materials are composed of light elements, and then we can ignore the spin-orbit-coupling effect and focus on the Heisenberg interactions. The resulting magnetic stability manifests a distinct chemical trend; VCl_2 and $MnCl_2$ show the 120° AFM ground states, and $NiCl_2$ shows the FM ground state. To understand the microscopic mechanism behind the magnetic interaction, we extracted the exchange coupling constants and the hopping integrals via the Wannier-function scheme. We also referred to Goodenough-Kanamori-Anderson rules to explain the trend of magnetic interaction. Our result highlights the role of the particular orbital states responsible both for the direct and superexchange interaction in 2D magnetism.

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Long spin diffusion length in epitaxial Pt wires.

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Polycrystalline platinum is a commonly used spin Hall (SH) material with a good SH angle but a small spin diffusion length due to the strong spin-orbit coupling.[1]. We recently found that an epitaxially grown Pt exhibits a long spin diffusion length of about 100 nm.[2]. In this study, we measured the non-local SH effect using epitaxial and polycrystalline Pt H-shaped devices [3] to determine their spin diffusion lengths and SH angles.

Figure (a) shows fabricated H-shaped epitaxial and polycrystalline platinum nanostructures. An applied current along the left arm generates a diffusive spin current in the horizontal bar via the SHE. The spin current then diffuses into the right arm and is converted back to the charge current via the inverse SHE. The voltage is detected as a non-local voltage. The non-local resistance comprises three contributions including the SHE contribution. Using the optimized structure, we extracted the SHE contribution from the systematic temperature dependence measurements.

The polycrystalline and epitaxial Pt device results are shown in Figs. (b) and (c), respectively. Interestingly, the $(R_{nl}/R_0)_{poly}$ remains constant; in contrast, the $(R_{nl}/R_0)_{Epi}$ exhibits a clear signature of the SHE contribution. Our results suggest that the spin diffusion length of epitaxial platinum exceeds 100 nm.

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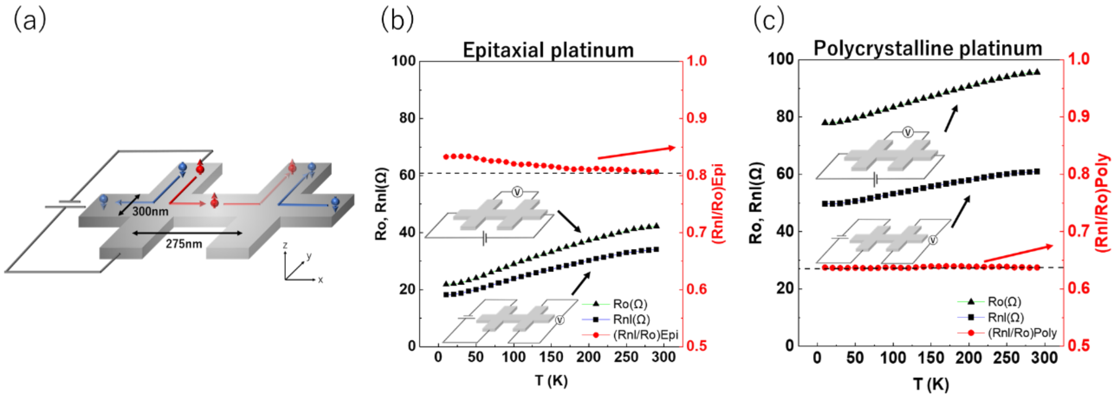
(a)
300nm
275nm
z
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(b)
Epitaxial platinum
Ro, Rnl(Ω)
(Rnl/Ro)Epi
T (K)
V
Ro(Ω)
Rnl(Ω)
(Rnl/Ro)Epi
(c)
Polycrystalline platinum
Ro, Rnl(Ω)
(Rnl/Ro)Poly
T (K)
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Rnl(Ω)
(Rnl/Ro)Poly

Spin-orbit and orbital torque in (W or Cr)/CoFeB/MgO stacks for SOT-MRAM application

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As a replacement for spin-orbit torque (SOT)[1], orbital torque (OT)[2] has attracted significant attention since theoretical predictions that the orbital Hall conductivity could be one order of magnitude larger than the spin Hall conductivity in heavy metals[3,4]; the latter has been intensively studied for SOT-magnetoresistive random access memory (MRAM)[5]. However, a systematic study on OT in stacks compatible with the SOT-MRAM application is missing. Here, we comparatively evaluate SOT and OT in NM (= Cr or W)/CoFeB/MgO stack compatible with SOT-MRAM application. Note that Cr is expected to generate large OT, whereas W has been used in SOT-MRAM demonstrations[5].

Figure 1(a,b) shows the stack structure of Cr/CoFeB/MgO and W/CoFeB/MgO, respectively. We varied NM and CoFeB layer thicknesses and evaluated the spin-orbital Hall conductivity ($\sigma_{LS}^{\mathrm{eff}}$) using a harmonic Hall technique. We find that $\sigma_{LS}^{\mathrm{eff}}$ in Cr/CoFeB/MgO is positive and increases with increasing Cr and CoFeB thicknesses, consistent with the previous reports on OT. Meanwhile, $\sigma_{LS}^{\mathrm{eff}}$ in W/CoFeB/MgO shows a cross-over, *i.e.*, a large negative $\sigma_{LS}^{\mathrm{eff}}$ is obtained when both W and CoFeB are thin whereas the sign changes to positive with increasing their thicknesses. These results give a new insight in the material engineering for SOT-MRAM applications.

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Spin-pumping driven by non-linear harmonic generation

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Non-linear systems, which are maintained in non-equilibrium steady states, host a wide range of functionally relevant properties that cannot be realized in thermal equilibrium. A common situation occurring in non-linear media is the simultaneous excitation and interaction of many non-coherent oscillatory degrees of freedom, where the energy distribution of these degrees of freedom give rise to multitude of physical phenomena such as phase-transitions and bistability [1]. In a system when sub-harmonic and second-harmonic modes are coherently excited, then the two generation processes can compete. For certain excitation amplitude the system enters in a bistable regime [2].

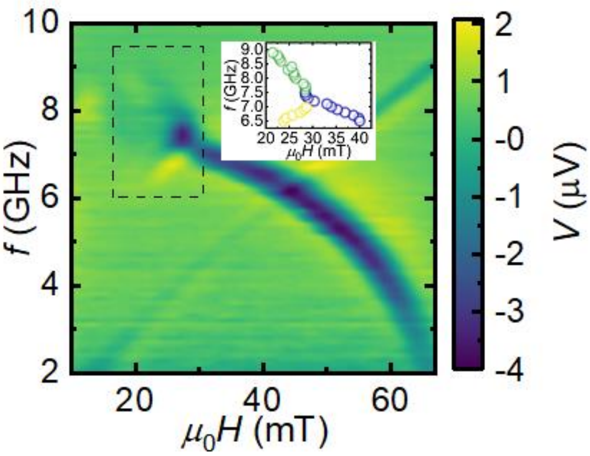

Fig 1. Color map showing the ISHE voltage obtained as a function of frequency and applied field. When optical mode frequency is twice of acoustic mode (~7 GHz), the optical mode bifurcates into two branches with opposite polarity. The inset shows the mode bifurcation.

In this work we demonstrate the effect of such non-linear interaction of sub and second harmonic modes on the spin-pumping. The system we use is a multi-layer structure of two ferromagnetic layers separated by a non-magnetic spacer (CoFeB/Ru/CoFeB). The microwave field, h was used to resonantly excite two modes (acoustic and optical) which induced a spin current in neighboring metal (Ta) that was detected through inverse spin-Hall effect (ISHE). For certain microwave amplitude, an enhancement is seen in spin current for optical mode at 2f frequency with a discontinuity (Fig.1) and the mode bifurcates into two branches with opposite polarity showing phase transition.

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Title: Nonlinear optical response of a s-wave superconductor NbN with using terahertz vortex beam

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Abstract (up to 200 words)

In superconductors, an amplitude fluctuation of the superconducting order parameter called Higgs mode exists with its energy located around the superconducting gap 2Δ. While the experimental observation of the Higgs mode has long been elusive over decades, recent terahertz (THz) nonlinear spectroscopy has revealed its presence experimentally by the intense THz pulse-induced quench experiments [1], and the THz pulse drive experiments [2]. In the latter case, Higgs-mediated THz third harmonic generation (THG) was observed revealing the nonlinear coupling between Higgs mode and the electromagnetic field [2].

In this study, we investigated the interaction of the Higgs mode with a THz vortex beam which possesses a spiral phase front and carries orbital angular momentum. We performed THz pump – THz probe spectroscopy in a s-wave superconductor Niobium nitride (NbN). Based on the experimental results, we will discuss the coupling between Higgs mode and THz vortex beam.

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Title: Quantum-classical correspondence and dissipative to dissipationless crossover in magneto-transport phenomena

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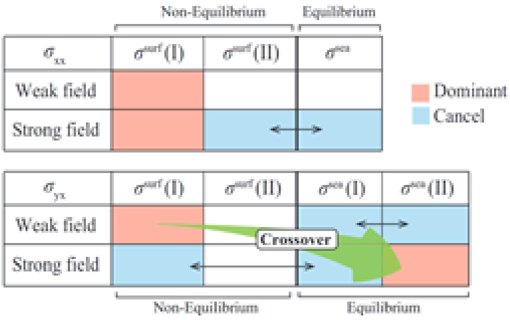
Abstract

Classical transport formula must be modified when the effect of Landau quantization is remarkable. In previous research [1,2,3], a general representation of magneto-transport tensors was derived and the effects of several types of scattering in semiconductors were studied precisely. However, correspondence between classical and quantum theory in arbitrary magnetic fields has not been obtained.

We derived a magneto-conductivity tensor based on the Landau quantization in free electrons. The correspondence to the classical theory is apparent in our representation [4]. Although it includes microscopic parameters, they can be renormalized into the macroscopic observables. Hence, parameter fitting is accessible and applicable to the analysis of experiments. Quantum effects are renormalized into the oscillation in the diagonal components.

A remarkable point is that the Hall conductivity shows a crossover from non-equilibrium to equilibrium transport because the non-equilibrium component is canceled with one of the equilibrium terms (Fig.1). In other words, the magneto-conductivity is non-dissipative at a high field limit. This equilibrium transport has a common origin with the quantum Hall effect in two-dimensional systems [5]. We pointed out that the crossover is observable as the phase shift of quantum oscillation in three-dimensional semimetals, while the quantization of Hall conductivity is unexpected.



(Fig.1) Contributions to each component in magnetoconductivity tensor

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Superconductivity in Hole-Doped Perovskite Hydride $KMgH_3$

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In our work, the stability and superconductivity of hole-doped perovskite hydride KMgH3 with varying lattice parameters, corresponding to different pressures, are studied from first-principles. KMgH3 is a stable perovskite hydride [1], and it has relatively strong lattice vibrations and a peak in the density of states just below Fermi level, making it a promising candidate for high-temperature superconductivity after hole-doping. We applied uniform hole doping to KMgH3, which leads to a larger density of states at Fermi level as the doping concentration gets larger. Lattice anharmonicity was treated by means of the self-consistent phonon (SCPH) method implemented in ALAMODE [2][3]. Firstly, we studied the stability of the doped compound, and we found that the doped compound gradually loses its mechanical stability with shrinking cell and increasing doping concentration, but anharmonicity considerably contributes to restoring the stability. After the investigation of the stability, calculations of electron-phonon coupling strength λ was carried out, and the superconducting transition temperatures was estimated for different pressures and doping concentrations.

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Title:
Developing Innovative Hard X-ray Spectral Imager for Studies of Particle Acceleration in Solar Flares

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Abstract (up to 200 words)

For understanding the particle acceleration in various scale plasma environments by the release of magnetic energy through magnetic reconnection, solar flares are unique observational targets in that they are bright in multi-wavelength and spatially resolvable. Focusing Optics X-ray Solar Imager (FOXSI) is the solar-dedicated X-ray sounding rocket mission to realize the direct imaging method combined with Wolter-I focusing optics and fine-pitch focal plane detectors. The fourth flight FOXSI-4 [1], scheduled in April 2024, aims to realize the world's first imaging spectroscopic observation of mid-large class solar flares, while the past three flights targeted the relatively quiet regions of the Sun. Our group is responsible for developing hard X-ray focal plane detectors. To meet the new requirements for observing solar flares, we developed a wide-gap CdTe semiconductor double-sided strip detector (CdTe-DSD) [2]. We seamlessly evaluated performance and developed response functions, simulations, and data acquisition systems.

In this presentation, we will give an overview of the FOXSI experiment, details of the wide-gap CdTe-DSD, and the status of preparations for FOXSI-4 for the launch in Apr 2024.

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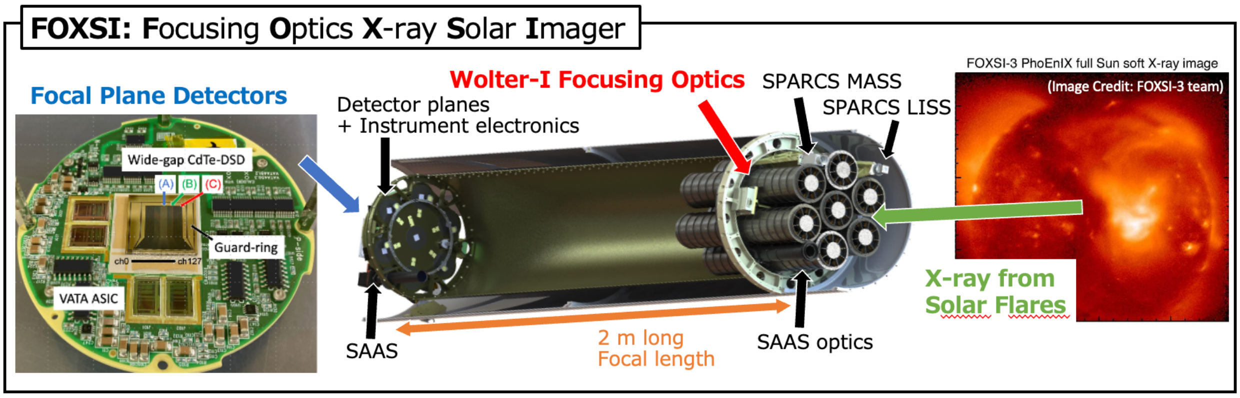

Fig. Schematic diagram of FOXSI payload (Image Credit: FOXSI-3 team)

Title: Observation of Spin Hall Conductivity Spectrum of GaAs in the Terahertz Frequency Regime

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Abstract (up to 200 words)

In the spin-orbit coupled systems, the carrier flow under a bias field is deflected into transverse directions dependent on their spins due to the Berry-curvature mechanism or impurity scattering, resulting in the spin current. This is known as the spin Hall effect (SHE) [1]. The SHE and its reciprocal process, the inverse spin Hall effect (ISHE), are crucial ingredients for the conversion between charge current and spin current in spintronics. However, conventional quasi-static measurements have difficulty revealing their microscopic mechanisms. What is essential is the information on dynamics faster than the impurity scattering rate, which typically lies on the terahertz (THz) frequency regime.

In this presentation, we report the first observation of the spin Hall conductivity spectrum of GaAs by THz polarimetry with a near-infrared (NIR) pump pulse [2]. After the spin injection by the NIR pump, our highly precise THz polarimetry detects the Faraday rotation due to the ISHE. The obtained spin Hall conductivity spectrum shows an excellent agreement with theories [3], demonstrating a crossover in the dominant origin from impurity scattering in the dc regime to the Berry-curvature mechanism in the THz regime. Our THz-spectroscopic approach paves the way to clearly resolve microscopic mechanisms of the SHE.

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Hiroto Saito

We have developed an efficient method for accurately calculating magnetic anisotropy. This method involves creating a Wannier basis tight-binding model using first-principles calculations and considering the crystal and spin symmetry. Furthermore, this approach employs time-reversal symmetry to distinguish magnetization from spin-orbit interactions, making it easy to generate Hamiltonians with magnetization oriented in any direction without requiring additional DFT calculations each time.
To validate our method, we apply it to calculate the magnetocrystalline anisotropy energy (MCAE) of L1_0-type FePt and FeNi. Our results show excellent agreement with previous studies on the chemical potential dependence of the MCAE. Additionally, we obtain the full angle dependence of the MCAE on the direction of magnetization. These findings provide a deeper understanding of magnetic properties and offer potential applications in various fields.

Magnetic studies of epitaxial thin films of noncollinear Weyl antiferromagnet Mn_3Sn

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Non-collinear antiferromagnetic (AFM) Mn_3Sn has shown highly advantageous FM-like properties [1,2]. The spin structure of Mn_3Sn is the result of a fine balance between several different interactions, therefore, even minute structural changes will have a great impact. Magnetometry is an indispensable investigation tool here, however due to nearly perfect moment cancelation of the AFM thin layers their magnetic signals are at the verge of practical detection limits of standard volume magnetometry. The unavoidable presence of bulky substrates, supporting the thin films, additionally strongly confuses the response of Mn_3Sn layers.

We present results of magnetometry studies obtained for epitaxial $Mn_3Sn(t)$ layers deposited by magnetron sputtering on MgO(110) single-crystal substrates (10 nm $< t <$ 100 nm) [3]. Firstly, we show a practical method of elimination of the spurious magnetic signals of MgO. We achieve this by adopting the concept of *in situ* compensation, elaborated previously to mitigate contributions brought about by bulky substrates [4]. Secondly, we present and discuss the thickness dependence of the spontaneous magnetization and critical temperatures. We find that all these characteristics correlate with the lattice parameter. Finally, we present comparison between results of magnetometry and of anomalous Hall effect.

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Acknowledgements: This study has been partly supported by TUMUG Support Program from Center for Diversity, Equity, and Inclusion, Tohoku University, and by JSPS Kakenhi 19H05622, 21J23061, 22K14558, and 22KK0072.

Title: 3D Topological insulator in a strong magnetic field

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Abstract

– Magnetic fields have significantly influenced the landscape of condensed matter physics, particularly in terms of electronic properties. Especially, the quantum hall effect highlighted the significance of topology in condensed matter [1]. Nowadays, with the development of moiré materials and high magnetic field environments, the relationship between topology and magnetic fields has received renewed attention. Especially, both theoretical and experimental attention has been focused on the occurrence of gap-closing behavior in the topological insulator at high magnetic fields, reflecting the absence of symmetric, exponentially localized Wannier functions in topological insulators [2-4]. In this poster presentation, we focus on the behavior of 3D topological insulators (3D Bernevig-Hughes-Zhang model) in strong magnetic fields and report some chiral separation effects [7] in the vicinity of gap-closing magnetic flux.

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Ti-Doping Effect in Weyl Antiferromagnet Mn_3Sn:

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Topological antiferromagnets has been considered promising candidates in spintronics because of their intrinsic properties including superfast spin dynamics and elimination of stray fields [1]. In particular, Mn_3Sn has attracted much attention for its special triangular AFM spin configuration in the Kagome plane, showing evidence of Weyl points near the Fermi surface [2]. We here present our results of spin texture tuning by introducing Ti atoms as dopant into this system while keeping the lattice structure. Approx. 10% Mn-site doped single crystals with $T_N \approx 395K$ is acquired. Our doped samples show modified magnetic properties and strongly anisotropic electrical transport behavior. With such findings, we can expect better tuning of magnetic properties and strength of electron interactions, and thus gaining deeper understanding in the role of band topology, magnetism and correlated effects in such doped systems.

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Title: The Status of the Simons Array Experiment and the Science Cases with Circular Polarization Measurements

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Abstract (up to 200 words)
Observations of mm-wave polarization provide rich information in understanding the universe [1, 2]. Circular polarization can explore beyond-the-standard-model signals such as galactic synchrotron emission, which is intrinsically circularly polarized, faraday conversion by Population (Pop) 3 stars, Lorentz violation, and others. However, accurate observation of circular polarization is challenging, and only little has been studied because the signals are estimated to be very small. The Simons Array (SA), an ongoing experiment on the Atacama plateau in Chile, aims to measure polarizations accurately. The second telescope achieved the first light recently. In this poster, we discuss the status of the SA and science cases with the circular polarization measurements.

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Title: Magnetic imaging of quantum vortices in microfabricated superconductor using diamond quantum sensor

Shunsuke Nishimura[1], Taku Kobayashi[1], Daichi Sasaki[1], Takeyuki Tsuji[2], Takayuki Iwasaki[2], Mutsuko Hatano[2], Kento Sasaki[1], Kensuke Kobayashi[1]
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Abstract

Superconductors exhibit a phenomenon known as quantum vortices due to the quantization of magnetic flux penetrating them [1]. These vortices are significant for their pairing symmetry and electromagnetic response near transition points, and have been studied using various visualization methods. Recently, a novel measurement approach utilizing nitrogen-vacancy (NV) centers in diamonds, known as quantum diamond microscopy (QDM), has emerged, garnering attention as a probe for magnetic field distribution. This method offers access to previously elusive information, such as the quantification of flux density and its fluctuation [2].

In this research, we apply this method to measure quantum vortices in a high-T_c superconductor, $YBa_2Cu_3O_{7-\delta}$ thin film, using a thin sensor layer of NV ensembles [3], which are all aligned to the surface. We obtained a quantitative magnetic image of the stray field around quantum vortices, over a broad field of view [4]. Furthermore, we determine the temperature dependence of the magnetic penetration depth from field distribution around vortex, replicating findings from previous research.

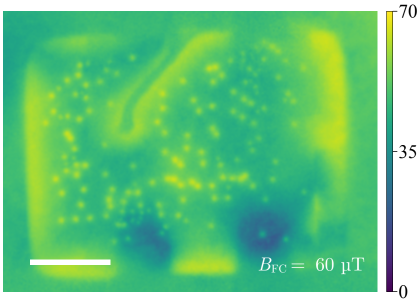

Figure. Imaging of stray field distribution around quantum vortices on $YBa_2Cu_3O_{7-\delta}$ thin film. This device is fabricated in the shape of a Hall bar, and the superconductor corresponds to the rectangular area in the center of the figure.

Our approach demonstrates broad applicability especially to superconducting quantum vortices under various conditions, supporting the use of QDM for exploring physical properties under severe conditions. In this presentation, we also show results on a microfabricated superconductor hall device (see Figure) as a basis for measurements of vortex dynamics.

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Antiferromagnetic magnonic charge current generation via ultrafast optical excitation

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Abstract

Néel spin-orbit torque (NSOT) allows a charge current pulse to efficiently manipulate the Néel vector in antiferromagnets, which offers a unique opportunity for ultrahigh density information storage with high speed. However, the reciprocal process of Néel spin-orbit torque, the generation of ultrafast charge current in antiferromagnets has not been demonstrated. Here, we report the experimental observation of charge current generation in antiferromagnetic metallic Mn_2Au thin films using ultrafast optical excitation. The ultrafast laser pulse excites antiferromagnetic magnons, resulting in instantaneous non-equilibrium spin polarization at the antiferromagnetic spin sublattices with broken spatial symmetry. This staggered spin polarization of the electrons is directly converted into a charge current by spin-orbit coupling due to the local inversion symmetry breaking. The magnonic charge current can be expressed as $\boldsymbol{J} \propto \boldsymbol{\sigma}_{\mathrm{A,B}} \times \hat{\boldsymbol{z}}$, where the charge current $\boldsymbol{J}$ and spin polarization $\boldsymbol{\sigma}_{\mathrm{A,B}}$ are orthogonal. The observed AFM magnonic charge current generated from the magnetic moment fluctuation can be a favorable building block for antiferromagnetic THz emitter and provides a promising platform to deepen the understanding of NSOT from the view of Onsager reciprocity. Besides the fundamental significance on the Onsager reciprocity, the observed magnonic charge current generation in antiferromagnet would advance the development of antiferromagnetic THz emitter.

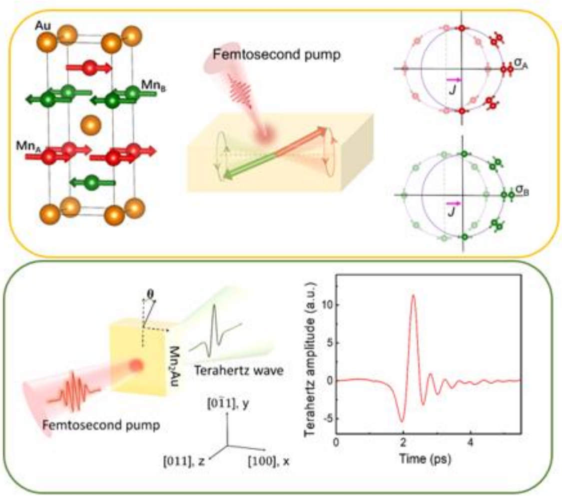

Figure Principle of magnonic charge current generation in Mn_2Au and Experimental setup and THz spectrum.

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Title: Stochastic Reaction-Diffusion System of Biological Chemical Reaction Network

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Abstract (up to 200 words)

Biological reaction systems are non-equilibrium open many-body systems, which share similarities with quantum many-body systems in which electrons and spins interact intricately. Based on this point, it is known that a stochastic quantum many-body system can be defined from a chemical reaction network (CRN) [1, 2]. In other words, the properties of CRNs can be understood by analyzing the corresponding non-Hermitian Hamiltonians. In this study, we define a non-Hermitian Hamiltonian from the cAMP-producing system, which is responsible for the regulation of gene transcription, and provide a basis for numerical investigation of the dynamics of the system.

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Magnetic Raman spectroscopy for Majorana edge states in Kitaev spin liquids

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The Kitaev honeycomb model can be mapped to a free Majorana fermion (MF) system [1]. The ground state is characterized by the itinerant MFs with a uniform Z_2 gauge field. Depending on the anisotropy of the exchange interactions, the ground state has the two topologically distinct phases (the A and B phase).

We study the magnetic Raman spectra [2,3] for the Majorana edge state (MES) in the A phase. Firstly, the flat band of MES acquires the sine curved dispersion when a magnetic field is applied. Then, we find the Raman intensity is enhanced by the Van Hove singularity in the dispersion of MES. Secondly, we consider the situation where the MESs at both edges are correlated due to the finite size effect. We reveal that the correlation of the MESs strongly depends on the anisotropy of the exchange interactions, and the resulting correlation also changes the frequency dependence of the magnetic Raman spectra. These results are different from the MES in the B phase [4] and present a unique signature of the MES in the A phase.

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X-ray magnetic circular dichroism arising from the magnetic dipole moment in Mn_3Sn and Mn_3Ir

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Recently, there has been considerable interest in antiferromagnetic materials that have magnetic symmetry compatible with the ferromagnetic state. In such materials, physical properties that were known to be specific to ferromagnets are observed. Here, we focus on one of such examples, the X-ray magnetic circular dichroism (XMCD) spectra for noncollinear antiferromagnets, Mn_3Sn and Mn_3Ir. By employing the differential form of the sum rules, we theoretically evaluate the XMCD spectra from first principles. We decompose the origin of the XMCD spectra into the contributions of spin magnetic moment, orbital magnetic moment, and magnetic dipole moment, and find that the contribution of magnetic dipole moment is dominant in these materials. We discuss that the cancellation of the contribution of spin magnetic moment comes from the symmetry in the case without spin-orbit couplings[1].

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Title: Charge-spin conversion in antiferromagnetic RuO_2

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Abstract (up to 200 words)

The relativistic spin Hall effect (SHE) and inverse spin Hall effect (ISHE) enable the efficient generation and detection of spin current. Nevertheless, the spin polarization is limited to the direction orthogonal to both charge and spin current. In contrast, a novel relativistic mechanism of spin-charge conversion, termed as altermagnetic spin splitting effect (ASSE), was theoretically predicted. [1,2] This poster presents experimental evidence of SST and the inverse effect in collinear antiferromagnetic RuO_2 films. First, according to spin torque ferromagnetic resonance (ST-FMR) measurements of RuO_2 films, we exhibit that spin current direction is correlated to the crystal orientation of RuO_2 and spin polarization direction is parallel to the Néel vector, indicating the existence of SST in RuO_2. [3] Second, based on spin Seebeck effect and THz emission measurements, we demonstrate that inverse ASSE can convert spin current polarized along Néel vector into charge current, which manifests as Néel vector-dependent spin Seebeck voltage signals and THz emission signal. [4,5] These findings not only present a new member for the spin torques besides traditional STT and SOT, but also proposes RuO_2 for both promising spin source and spin sink in spintronic devices.

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Detection of magnetic octupolar order by nonlinear magnetoelectric effect

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Emergence of ordered states associated with symmetry lowering has brought much diversity to condensed matter physics, one of which is multipolar order. For example, antiferromagnets with time-reversal symmetry breaking such as Mn_3Sn [1] and all-in all-out pyrochlore Iridates [2] have clustered magnetic octupolar order. Altermagnets such as RuO_2 and MnF_2 have been also considered to have magnetic octupolar order [3].

On the other hand, methods for directly observing and controlling higher-order multipoles are still in their infancy. One of them is to use response phenomena from Neumann's principle. For example, the linear magneto-optic Kerr effect has been successfully used to control the domain for magnets due to activated magnetic dipoles. However, it must be extended to nonlinear responses for materials where lower-order multipoles are inactive and higher-order ones are active [4][5].

In this study, we propose the nonlinear magnetoelectric effect as a probe of magnetic octupolar order. Specifically, we perform model calculations of the nonlinear magnetoelectric tensor for pyrochlore substances and RuO_2 with the lowest-ranked magnetic octupoles. This study not only provides a new probe of magnetic octupoles, but also encourages the use of nonlinear responses to investigate multipolar order experimentally.

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Title: Effect of Y-doping on the high-temperature antiferromagnet Ba5Co5ClO13

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Abstract (up to 200 words)

This study explores the potential for inducing superconductivity in a compound with high antiferromagnetism. The quest for unconventional superconductivity in high-temperature antiferromagnet has attracted extensive research interests [1], and our investigation aims to discover something new from the specific antiferromagnet.

Here, we investigate the effects of Y doping into $Ba_5Co_5ClO_{13}$, characterized by high-temperature antiferromagnetism with a Neel temperature of 135 K [2][3]. The primary objective is to suppress its antiferromagnetic order and explore the possibility of realizing unconventional superconductivity by systemically changing the lattice size. For this purpose, we selected Y as the dopant, whose ionic radius is similar to Ba. By combining single-crystal X-ray diffraction (XRD) with magnetic and electrical transport measurements, we obtain new insights into the connection between structural properties and antiferromagnetism in $Ba_5Co_5ClO_{13}$ under controllable doping.

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Fabrication of tunnel junction with the antiferromagnetic Weyl semimetal Mn_3Sn dot down to sub-micron scale

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Antiferromagnetic spintronics has attracted much attention in recent years because of its potential for ultrafast magnetization dynamics, robustness against magnetic field perturbations, and the absence of stray fields [1-3]. While various methods exist for electrically detecting AFM order, efficient detection, particularly at submicron scale, has remained elusive. Recently, magnetic tunnel junctions based on non-colinear antiferromagnets such as Mn_3Sn [4] and Mn_3Pt [5] have been reported. These may be used to efficiently detect antiferromagnetic states, potentially much larger voltage signal than the anomalous Hall effect found in the antiferromagnetic Weyl semimetals [6]. The junction size in our previous report was 10 μm^2 [4]. In this study, we successfully reduced the junction size to ~0.3 μm^2 in an Fe/MgO/Mn_3Sn MTJ.

The multilayer films were prepared using molecular beam epitaxy and sputtering. Distinct magnetization switching processes for Mn_3Sn and Fe were observed as revealed by the magneto-optical Kerr effect (Fig.1a). The magnetic tunnel junctions were fabricated using electron beam lithography and Ar ion etching (Fig.1b). Magnetoresistance was observed at the fields corresponding to expected magnetization reversal. These results enable further studies for the magnetization process in sub-micron Mn_3Sn dots and pave the way for developing antiferromagnetic device application.

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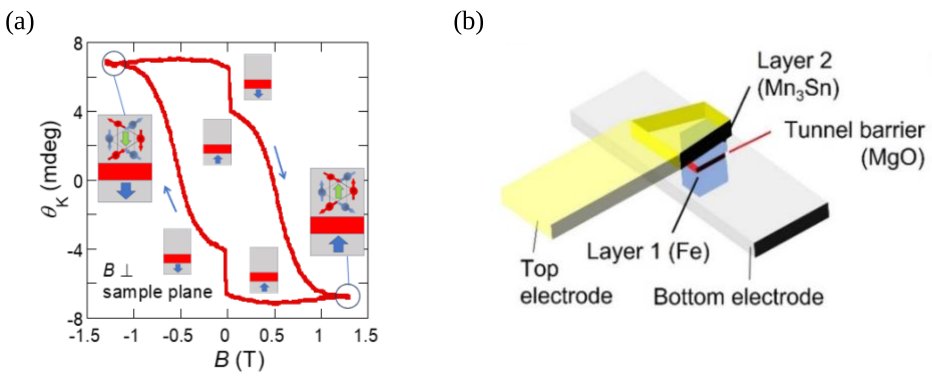

Figure 1 (a) Magnetization hysteresis curve of Fe/MgO/Mn_3Sn film measured using magneto-optical Kerr signal. (b) Schematic of the magnetic tunnel junction.

Data-driven self-calibration of quantum circuits

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Any circuit is in one-to-one correspondence with a logical table that specifies, upon any given input state, what the output state of the ideal circuit should be. Since classical states are perfectly distinguishable in principle, at least at a fundamental level the calibration of classical circuits does not therefore present any difficulty. This is in stark contrast with the quantum case where, due to the existence of superposition of states, neither input nor output states can in general be jointly distinguished perfectly, thus rendering the calibration of quantum circuits a problem in principle.

Here, we address this fundamental issue by adopting a Bayesian approach to the calibration of quantum circuits that is *data-driven*, i.e. it avoids any assumption on the quantum description of the states input and output of the circuit, and solely relies on correlations between their classical labels, thus de facto representing a self-calibration of the circuit. In particular, our approach automatically inherits from Bayes theorem an *Occam's razor*-like minimality criterion that favors the simplest inference that is consistent with the observations. We show that data-driven self-calibration is equivalent to a particular clustering problem in the correlation space that can be solved adopting John's theory on minimum volume enclosing ellipsoids.

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Tingyu Zhang

Spin transport phenomena at strongly-correlated interfaces play central roles in fundamental physics as well as spintronic applications. In this presentation we talk about the spin tunneling and the shot noise in an itinerant Fermi gas. We investigate the spin current induced by quasiparticle and spin-flip tunneling processes by applying a two-terminal model. The interaction dependence of the spin current indicates an enhanced magnon tunneling in the strong-coupling regime, and a characteristic behavior around the critical repulsive strength for ferromagnetic phase transition at low temperatures.

To anatomize spin-transport carriers, we propose the detection of the spin current noise in interacting itinerant fermions. The Fano factor given by the ratio between the spin current and its noise reflects elementary carriers of spin transport at the interface of spin-polarized Fermi gases realized in ultracold atoms. The change of the Fano factor microscopically evinces a crossover from the quasiparticle transport to magnon transport in itinerant fermionic systems.

Thermal Hall measurements to detect spontaneous thermal Hall effect in kagome superconductor CsV_3Sb_5

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Chiral superconductivity, breaking time-reversal symmetry, has attracted attentions as a topological superconductor characterized by bulk quasiparticle bands with non-trivial topological numbers.

Experimentally, some candidates of chiral superconductors are suggested mainly by μSR and Kerr effect measurements [1,2]. However, these methods have difficulties in quantitative evaluations, and lacking considerations from a topological perspective.

Focusing on topological properties, we propose thermal Hall measurements as a new experimental approach. In chiral superconductivity, it is theoretically expected that quasiparticles carrying heat can be observed as a spontaneous thermal Hall effect at the zero field [3]. By performing spontaneous thermal Hall measurements, we expect to enable the direct observation of the Chern number that reflects the topological nature, advancing towards quantitative verification with theory.

In this poster, we report our trials to detect the spontaneous thermal Hall effect in the kagome superconductor CsV_3Sb_5. For the superconducting state in kagome lattices, unconventional superconductivity such as extended s-wave, chiral p-wave, and chiral d-wave has been theoretically predicted [4]. Indeed, the potential realization of chiral superconductivity in this compound has been suggested [5].

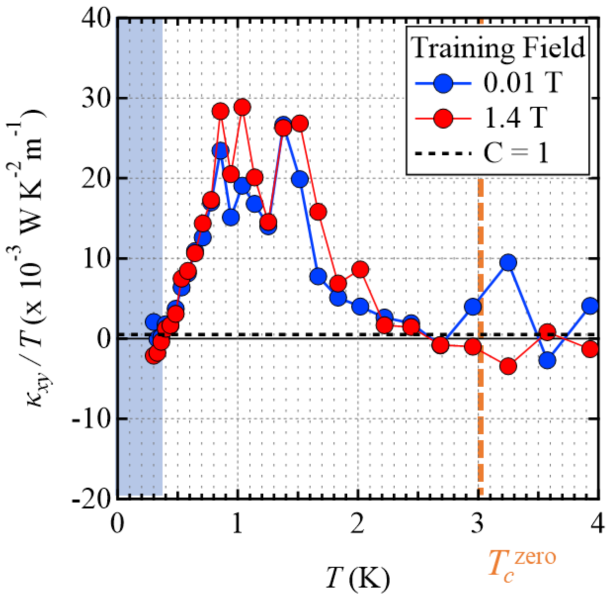

Fig1. The temperature dependence of κ_{xy} / T

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Title: Development of low temperature relaxation-method calorimetry for small samples

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Abstract (up to 200 words)

In solid state physics, specific heat is one of the most fundamental thermodynamic quantities, reflecting the electronic, spin and lattice degree of freedom. Especially, specific heat at ultra-low temperature is especially important for the study of quantum many-body effect and quantum magnetism. In order to measure the specific heat for small samples (< 1 mg) accurately at ultra-low temperature, it is necessary to reduce the addenda heat capacity coming from the sample stage (1-3). In this presentation, we report the development of a new specific heat cell that allows us to measure the heat capacity by the relaxation method down to T ~ 20 mK. We could reduce the addenda heat capacity by adjusting the thermometer, heater, and thermal link etc.

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Title: NbReSi: a noncentrosymmetric superconductor with large upper critical field and nodeless superconductivity

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We report the discovery of superconductivity in noncentrosymmetric NbReSi, which crystallizes in a hexagonal ZrNiAl-type crystal structure with space group P-62m. Bulk superconductivity, with $T_c = 6.5$ K was characterized via electrical-resistivity, magnetization, and heat-capacity measurements. A large upper critical field of $\mu_0 H_{c2}(0)$~12.6 T is obtained, which is comparable to the weak-coupling Pauli limit. The low-temperature electronic specific heat, superfluid density $\rho_{sc}(T)$ (determined via transverse-field muon-spin rotation and relaxation (μSR)) and the spin-lattice relaxation rate $T_1^{-1}(T)$ (determined via nuclear magnetic resonance (NMR)) suggest a nodeless superconductivity with signatures of multigap in NbReSi. The absence of spontaneous magnetic fields below T_c, as evidenced from zero-field μSR measurements, indicates a preserved time-reversal symmetry in the superconducting state of NbReSi. The electronic band-structure calculations show that the density of states at the Fermi level are dominated by Re and Nb d orbitals, with a sizable band splitting induced by the antisymmetric spin-orbit coupling. The unusually large upper critical field of NbReSi possibly arises from its anisotropic crystal structure.

NbReSi represents a new candidate material for revealing the puzzle of time-reversal symmetry breaking observed in some Re-based superconductors and its relation to the lack of inversion symmetry.

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Development of a circular polarized microwave cavity and microwave Hall effect measurements

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A microwave cavity has been used for electron spin/ferromagnetic resonance and surface impedance measurements in condensed matter physics [1]. More recently, it has also been a powerful tool in qubit control and the study of cavity quantum electrodynamics (cavity QED) [2].

In this study, we have developed a high-Q microwave dielectric cavity, which can generate and control circularly polarized eigenmodes by equipping a hybrid coupler (Fig. 1). It can maintain a high-Q value ($Q \sim 1 \times 10^5$) even in a high magnetic field, and the circular dichroism allows us to evaluate the conductivity susceptibility and impedance tensor, including the off-diagonal term. In this poster presentation, we will present the results of Hall effect measurements on Bi single crystals in the microwave region obtained from surface impedance tensors by using the developed circularly polarized cavity.

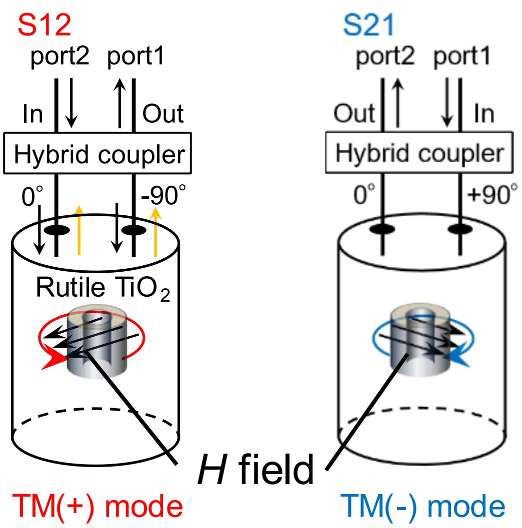

Fig.1 Our developed circularly polarized microwave dielectric cavity

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Analogue Hawking radiation with reverse Doppler shift in Josephson metamaterial transmission lines

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Abstract

We have shown that solitons exist in Josephson metamaterial nonlinear transmission lines due to their nonlinearity and dispersion, and that these solitons behave analogue black holes. We have also reported that analogue Hawking radiation occurs there due to quantum-mechanical effects [1]. Since the black-hole soliton travels along the transmission line, it is necessary to consider the Doppler effect when observing the Hawking radiation emitted from the soliton. In our system, which is a metamaterial transmission line with a negative reflection index, the phase velocity and group velocity travel in opposite directions, so unlike the conventional Doppler effect, there is a reverse Doppler effect [2] in which the frequency increases as the sound source moves away. We will discuss the Hawking temperature considering the reverse Doppler effect.

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Title: Defect density effect on scattering times in a γ-Al_2O_3/$SrTiO_3$ 2DEG

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Abstract (up to 200 words)
The γ-Al_2O_3/$SrTiO_3$ heterostructure interface is known to form a high-mobility two-dimensional electron gas (2DEG) at low-temperatures due to the presence of oxygen vacancies confined to the interface. Although the origin of the high-mobility and the influence of the γ-Al_2O_3 film growth conditions have been studied, the effect of cation defects at the interface, caused by the high kinetic energy of the atoms in the pulsed laser deposition (PLD) plume, on the transport characteristics has not been explored. The elastic, inelastic, and spin-orbit scattering lifetimes of carriers forming a 2DEG at the $LaAlO_3$/$SrTiO_3$ interface have been extracted with the Maekawa-Fukuyama (MF) model.[1]
In this work, the scattering lifetimes of carriers of the γ-Al_2O_3/$SrTiO_3$ 2DEG grown at various ablation plume kinetic energies were extracted by MF fitting of the magnetoconductance data. Fig. 1 shows the normalized magnetoconductance and MF fitting of the heterostructures in the 0 to 9T magnetic field range. It was possible to fit both low- and high-field regions by adding a Kohler component for the orbital magnetoresistance contribution. The effect of the laser fluence on the scattering lifetimes of these heterostructures will be presented.

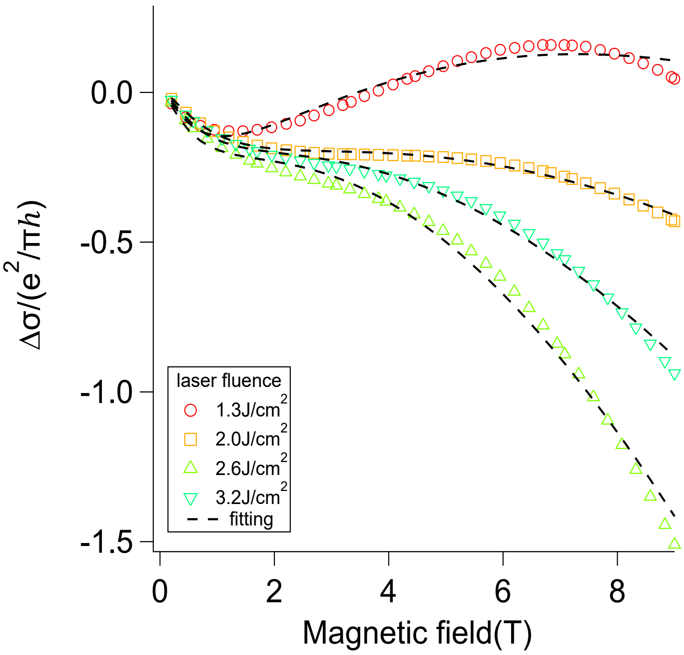

Fig. 1 Magnetoconductance fitting with the MF model for γ-Al_2O_3/$SrTiO_3$ heterostructures grown at various laser fluences.

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Anisotropic thermal expansion phenomena in Ca_2RuO_4 type systems

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Thermal strains in functional materials can seriously impede their device applications. It is thus, a technological imperative to minimize the thermal expansion of materials. Negative thermal expansion (NTE), a rare and interesting phenomenon observed in certain materials which contract upon heating, can be effectively harnessed to this end. Layered ruthenate Ca_2RuO_4 is one such material endowed with this characteristic. A giant NTE within a 200 K temperature window with a value of $\alpha_L \sim -115 \times 10^{-6}$ /K of the linear coefficient of thermal expansion was reported in this system recently[1], and the phenomenon was attributed to the observed anisotropic thermal expansion of the system[1,2]. Ca_2RuO_4, which crystallizes in a layered distorted K_2NiF_4 structure[2,3] undergoes multiple phase transition as a function of temperature with the metal-insulator transition below 357 K[4,5]. Formation of Ru 4*d* orbital ordered and antiferromagnetic ordered states were observed below 260 K and 110 K[6,7], respectively. In my presentation, I will elaborate upon the couplings between various order parameters and their impact on the thermal expansion properties of this system. Additionally, I will discuss our findings of high-throughput search for new NTE materials within layered K_2NiF_4 lattice framework.

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Title: Polarized Raman study of antiferromagnet $FePS_3$

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Abstract (up to 200 words)

Layered materials, characterized by van der Waals interaction as the interlayer coupling, exhibit versatile properties suitable for future device applications. $FePS_3$ is a compound of particular interest by its layered structure and antiferromagnetism. Below the Néel temperature, its spins align in a zigzag pattern. Raman spectroscopy, a widely used nondestructive method, allows for the study of vibrational and magnetic properties of materials. We conducted Raman spectroscopy on $FePS_3$ by using linear polarized light to investigate its properties. The polarization azimuth angle dependence of scattering intensity undergoes a significant change near the Néel temperature. Additionally, we found that the azimuth angle dependence below the Néel temperature can be explained by introducing a phase difference to the diagonal elements on the Raman tensor. This anisotropic nature is consistent with other low-symmetry layered materials, such as black phosphorus [1] or transition metal dichalcogenides [2]. These findings demonstrate that magnetic ordering induces in-plane anisotropy in the scattering intensity of $FePS_3$.

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Thermal Hall effect in the antiferromagnetic Skyrmion lattice

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Abstract

Magnon, a fundamental quasi-particle in magnetic materials, has attracted great attentions due to its intriguing heat and/or spin transport phenomena. One of the prominent phenomena is the thermal Hall effect. The magnon experiences the emergent gauge field originating from the nontrivial spin texture or antisymmetric exchange interaction, which results in the appearance of the transverse thermal conductivity. Indeed, the magnetic insulator GaV_4Se_8 which hosts a ferromagnetic Skyrmion lattice exhibits the magnon thermal Hall effect due to the U(1) gauge field generated by the magnetic vortices[1, 2]. In this presentation, we focus on the thermal transport properties on a new class of Skyrmion lattice, the antiferromagnetic (AFM) Skyrmion lattice composed of three sets of the ferromagnetic Skyrmion lattices[3]. We show the experimental observation of the thermal Hall effect in the three sub-lattice AFM SkL state realized in $MnSc_2S_4$[4]. The spin wave theory calculation show that the heat carriers can be described by the magnon in SU(3) gauge field originating from the three sub-lattice structure.

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Title: Magnetic resonance frequencies in a two-sublattice ferrimagnet with a magnetic compensation point

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Abstract (up to 200 words)
Ferrimagnetic materials are the materials that possess ferromagnetic or antiferromagnetic properties depending on the temperature, providing a rich platform for both physics and applications. However, the understanding of the dynamics of ferrimagnetic materials is still not fully developed due to the complexities at the magnetic compensation temperature where the net magnetization disappears. In order to overcome it, we obtained the resonance frequencies by analytically solving the Landau-Lifshitz-Gilbert equation for bismuth-substituted rare-earth iron garnet, a two-sublattice ferrimagnetic material. As the result, our solution is applicable across all temperature ranges, including the magnetic compensation temperature. Our calculation results are consistent with experimental findings obtained by Brillouin light scattering and pump-probe measurements, taking into account the exchange stiffness and the temperature dependence of magnetic anisotropy in the free energy. With this result, it is possible to enhance the understanding of magnetic dynamics of ferrimagnetic materials. Furthermore, the same approach can be applied for other ferrimagnetic materials with uniaxial anisotropy. Future prospects include the creation of new magnetooptical devices that utilize the fast magnetic response of ferrimagnetic materials over all temperature ranges.

Large Hall Signal due to electrical Switching at Mn3Sn/heavy metal multilayers

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The electrical manipulation of a topological state is crucial for utilizing the robust properties of topological materials in electronic devices. Recently, such manipulation is realized in the antiferromagnetic Weyl semimetal Mn_3Sn[1,2] through the readout signal of anomalous Hall effect in the Mn_3Sn/heavy metal (Pt, W) heterostructures[3]. Here, we reported that the switching of Hall signal of Mn_3Sn/heavy metal multilayer can be significantly enhanced by: (i)adjusting the crystal orientation of Mn_3Sn by removing Ru buffer layer, and (ii) changing the interfacial condition by annealing at the interface between Mn_3Sn and the heavy metal. Compared to the reported switching Hall signal in Ru/Mn_3Sn/Pt multilayers, the switching Hall resistance becomes one order larger, ~0.35 Ω, in the Mn_3Sn/W devices. The readout voltage can be increased to mV order by increasing the read current. Moreover, by investigating the thickness dependence of Mn_3Sn layer, we found that the effective switching thickness in Mn_3Sn layer could go up to 40nm, which is much thicker than ferromagnetic materials. Furthermore, we investigate the initial state dependence of the Mn_3Sn switching, and also the influence of the adding insertion layer Cu between Mn_3Sn heavy metal layer.

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Title: Extremely Large Magnetoresistance and Anisotropic Transport in Multipolar Kondo System $PrTi_2Al_{20}$

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Quadrupolar Kondo lattice (QKL) system $PrTi_2Al_{20}$ serves as a suitable platform for exploring exotic transport phenomena induced by multipole moments [1,2]. The investigation of the system's transport properties under magnetic fields involved the measurement of transverse magnetoresistance and Hall effect in both $PrTi_2Al_{20}$ and its non-4f analog, $LaTi_2Al_{20}$. At elevated temperatures, the transport behaviors of $PrTi_2Al_{20}$ notably diverge from those of $LaTi_2Al_{20}$, potentially due to quadrupole-induced scattering. Conversely, at lower temperatures, both systems exhibit comparable characteristics, displaying unsaturated and significantly large quasi-linear magnetoresistance attributed to the open orbits mechanism [3].

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Composition variation behavior of galvanomagnetic effect in GdFe collinear coupled ferrimagnetic alloy thin films

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Abstract (up to 200 words)
We focus on the electron transport phenomena in ferrimagnetic alloys with collinear antiferromagnetic spin subnetworks. These phenomena are expected to be used to electrically detect magnetic information via the anomalous Hall effect (AHE) and to harvest energy from the environment via the anomalous Nernst effect (ANE)[1]. In this study, we investigated GdFe alloy thin films. The longitudinal resistance ρ_{xx} and the lateral resistance ρ_{xy} were measured for various composition ratios of Gd and Fe. Then the AHE and ANE were evaluated. The AHE and ANE increased significantly with the addition of Gd to pure Fe, and showed non-linear variation with Gd composition, which has a local maximum[2]. Furthermore, in the ρ_{xx}-ρ_{xy} correlation, ρ_{xy} showed a larger ρ_{xx} dependence than that of typical ferromagnetic materials[3][4]. Additionally, we investigated the contribution of the AHE to the anomalous Nernst coefficient by measuring the Seebeck effect (SE) in this material.

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Anisotropic transport properties in transition metal dichalcogenide $TiSe_2$

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Transition metal dichalcogenides are materials in which two group 16 chalcogen elements are arranged in an octahedral or triangular prismatic configuration around a single transition metal element, often in a layered crystal structure[1]. Among them, TiS_2 is expected to exhibit various anisotropic transport properties because of its two-dimensional structure, in which Ti and S are arranged in an octahedron and Ti and S layers are stacked by van der Waals forces[2]. In addition, topological states have been observed in Ti compounds with Te and Se as chalcogen elements in $TiTe_2$ under high pressure [4] and superconductivity in $TiSe_2$ [5], and such phenomena are expected to occur in $TiSe_{2-x}Te_x$ as well[6].

Research has also been conducted on polycrystalline samples of TiS_2 sintered by spark plasma sintering (SPS)[3], a technique in which an electric current is applied under pressure and thermal and plasma energies are applied to sinter the sample. Anisotropic transport properties can be controlled by changing the composition ratio of Ti and S, taking advantage of the easy penetration of atoms into the van der Waals gap between layers[3]. In this study, polycrystalline samples of Ti_xS_2 and $TiSe_{2-x}Te_x$ with various composition ratios were synthesized by a two-step heat treatment involving solid phase reaction and SPS. The orientation and composition ratios were investigated by X-ray diffraction and SEM-EDX, and anisotropic transport properties were measured at low temperatures. The band gap was controlled by changing the composition ratio of $TiSe_{2-x}Te_x$, and physical phenomena near the metal-insulator transition were investigated. In this talk, we will discuss the results obtained from first-principles calculations and the transport properties and orientation in the SPS-supported polycrystalline samples Ti_xS_2 and $TiSe_{2-x}Te_x$.

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Title: Quantum Phases of Helium Three on Graphite Plated with Bilayer of HD

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Abstract (up to 200 words)

Helium three (3He) is an atom with nuclear spin 1/2. The atom is absorbed on graphite and regulated on two dimensions at low temperature. Therefore, 3He on graphite (3He/gr) enables us to research two-dimensional magnetism.

3He/gr undergoes structural phase transition when changing its areal density and shows various phases. From lower areal density, the system mainly has self-condensing phase, Fermi liquid phase, commensurate phase and incommensurate phase. Bare graphite is often plated with 3He, 4He, and hydrogen in order to corrugate the first layer of 3He.

For graphite plated with a bilayer of hydrogen, two phases with specific heat capacity were found [1]. Although those ground states are suggested to be quantum crystal liquid and quantum spin liquid, these microscopic structures have not been cleared [1]. In particular, one of the two ground states is considered to be an elementary excitation of Majorana Fermion [1].

Thus, the purpose of our research is to clarify the microscopic structures of the ground states of the two phases. The method is measuring spin-spin relaxation time and magnetic susceptibility with NMR.

Currently we prepare the NRM cell and the NMR system for the measurement.

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Large Spin-Orbit Coupling Systems for Emerging Physics and Spintronics Applications

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Abstract: Spintronics, which uses spin as the building block for information process, has become an emerging area in the Post-Moore ear. In order to address current challenges of spintronics, opportunities may exist for a focus research on the understanding and manipulation of fundamental spin-orbit coupling (SOC) in solid-state materials. In this talk, I will present our work on the control of spin/magnetic states in magnetic topological insulators and narrow bandgap semiconductor-based heterostructures. The independent manipulation of the topology of energy band and the magnetic exchange order enables us to construct non-reciprocal devices and novel artificial neural network computing paradigm. In addition, I will also summarize our work on utilizing interfacial Rashba SOC in lattice-matched InSb/CdTe heterostructures for realizing gate-tunable non-reciprocal charge transport and spin-orbit-torque-based magnetization switching with highly spin-to-charge conversion efficiency at room temperature. Our work may help construct a wide range of ultralow-power spin−orbitronics applications.

Biography: Dr. Xufeng Kou received his BS degree (with honor) in Chu Kochen Honors College from Zhejiang University (2009). From 2009 to 2015, he received his MS and PhD degrees in Electrical Engineering from UCLA. Since February 2016, he joined the School of Information Science and Technology at ShanghaiTech University. So far, Dr. Kou has published 3 book chapters, and co-authored more than 90 peer-reviewed journal/conference papers including Nature Electronics, Nature Materials, Nature Nanotechnology, Nature Communications, Physical Review Letters, and IEEE IEDM. with more than 7000 citations (h-index of 36). He also holds several awards including the Qualcomm Innovation Fellowship (2012), Chinese Outstanding Student Abroad Scholarship (2013), Distinguished PhD Dissertation Award of UCLA (2015), Shanghai May 4th Youth Medal (2018), Shanghai 35U35 Award (2021), and Shanghai Pudong Elite Researcher Award (2023).