

MAJORANA WORKSHOP 2026

Majorana Modes: Fundamentals, Status & Directions

WORKSHOP PROGRAM

OKOCHI HALL · RIKEN WAKO CAMPUS

WAKO, SAITAMA · JAPAN

TUTORIAL

13 OCTOBER 2026

TUESDAY · 13:00–17:40

**Introduction to Majorana modes:
four lectures**

PhD students & early arrivals

WORKSHOP

14–16 OCTOBER 2026

WEDNESDAY–FRIDAY

**5 plenary talks · 33 invited talks ·
poster session**

Invited speakers & registered participants

Workshop website: www.topoquantum.vip/majorana-7d394a68/

Organized by RIKEN iTHEMS · Supported by JST PRESTO (Quantum Cooperation), RIKEN FQSP,
and the RIKEN Pioneering Project “Mathematical Foundation of Quantum Information”

Organizers: Ching-Kai Chiu (RIKEN iTHEMS) · Thore Posske (University of Hamburg) · Yuichi Kasahara (Kyushu University)

Majorana Modes: Fundamentals, Status & Directions

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14–16 October 2026 | Okochi Hall, RIKEN Wako Campus, Japan

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Introduction to Majorana modes — a half-day introduction for graduate students and early workshop arrivals. Sessions by Posske (Kitaev chain), Klinovaja (topological superconductors), Pikulin (finding & using MZMs) and Moon (Kitaev spin liquids).	
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36 talks with a title, 34 of them with an abstract. Talks whose title is not yet announced (TBA) appear in the timetable only.	

WORKSHOP AT A GLANCE

3 DAYS · OCTOBER 14–16, 2026

Okochi Hall, RIKEN Wako Campus —
Wako, Saitama · Japan

WEBSITE www.topoquantum.vip/majorana-7d394a68/

Program as of October 14, 2026.

5 PLENARY + 33 INVITED TALKS

Poster flash talks and poster session on
Day 2; all times JST (UTC+9)



WORKSHOP WEBSITE

Majorana Modes: Fundamentals, Status & Directions

TUTORIAL

13 October 2026 | Okochi Hall, RIKEN Wako Campus, Japan

Tuesday, October 13 — Tutorial			DAY 0
TIME	SPEAKER	TALK TITLE	
13:00–14:00	Thore Posske University of Hamburg	Topological classification of Majorana modes & the Kitaev chain.	
14:00–14:10	Break		
14:10–15:10	Jelena Klinovaja University of Basel	Majoranas in topological superconductors and topological invariants.	
15:10–15:30	Coffee break — snacks and coffee provided		
15:30–16:30	Dmitry Pikulin Microsoft	Finding Majorana zero modes in a superconductor–semiconductor hybrid, and building a qubit out of them.	
16:30–16:40	Break		
16:40–17:40	Eun-Gook Moon KAIST	Kitaev spin liquids: exact solution, flux excitations, experimental signatures (α -RuCl ₃).	

Venue: Okochi Hall, RIKEN Wako Campus — 2-1 Hirosawa, Wako, Saitama 351-0198
Audience: PhD students & early arrivals · researchers in adjacent fields welcome

Majorana Modes: Fundamentals, Status & Directions

PROGRAM

14–16 October 2026 | Okochi Hall, RIKEN Wako Campus, Japan

Wednesday, October 14			DAY 1
TIME	SPEAKER	TALK TITLE	CHAIR
09:00–09:05	Fuchun Zhang Kavli ITS, UCAS	Opening Remarks	Ching-Kai Chiu RIKEN iTHEMS
09:05–09:10	Satoshi Iso RIKEN iTHEMS	Introduction to RIKEN iTHEMS	
09:10–10:00	PLENARY Jay D. Sau University of Maryland	Theorist's perspective on topological qubits in semiconductor nanowires: progress and challenges	Fuchun Zhang Kavli ITS, UCAS
10:00–10:25	Dmitry Pikulin Microsoft	TBA	
10:25–10:45	Coffee break — group photo		
10:45–11:10	Robert Peters Kyoto University	Neural Network Quantum States for Topological Quantum Spin Systems: From the Toric Code to the Kitaev Model	Thore Posske University of Hamburg
11:10–11:35	Shu Zhang Okinawa Institute of Science and Technology	Sensing and steering mobile topological defects in two dimensions	
11:35–12:50	Lunch — provided for all participants · Main Research Building (C01), 3F and 4F, east side		
12:50–13:15	Kumpei Imamura Kyoto University	Thermodynamic signatures of Majorana excitations in the Kitaev magnet α -RuCl ₃	Yuichi Kasahara Kyushu University
13:15–13:40	Eun-Gook Moon KAIST	Identification of a Kitaev Quantum Spin Liquid	
13:40–14:05	Gábor Halász Oak Ridge National Laboratory	Geometric probes of chiral Majorana edge modes in Kitaev spin liquids	
14:05–14:30	Dmitri Feldman Brown University	Interferometry revisited	
14:30–14:50	Coffee break		
14:50–15:15	Can-Li Song Tsinghua University	Majorana zero modes and their interplay with charge stripes in iron-pnictide films	Tetsuo Hanaguri RIKEN CEMS
15:15–15:40	Tong Zhang Fudan University	Observation of sharp and magnetic-field tunable zero-energy states in MnTe/Bi ₂ Te ₃ /NbSe ₂ heterostructure	
15:40–16:05	Hao Zheng Shanghai Jiao Tong University	Gating the Yu-Shiba-Rusinov states in Bi ₂ Te ₃ / NbSe ₂ heterostructures by a scanning tunneling microscope tip	
16:05–16:25	Coffee break		
16:25–16:50	Kam Tuen Law The Hong Kong University of Science and Technology	Quantum Anomalous Hall Insulator-based Majorana platforms	Xiao Hu Shanghai University
16:50–17:15	Sadashige Matsuo Institute of Science Tokyo	Control and detection of Andreev states via the wavefunction leakage	
17:15–17:40	Jelena Klinovaja University of Basel	Properties and prevalence of false poor man's Majoranas in two- and three-site artificial Kitaev chains	

Click a title to jump to its abstract. TBA: title not yet announced.

Majorana Modes: Fundamentals, Status & Directions

PROGRAM

14–16 October 2026 | Okochi Hall, RIKEN Wako Campus, Japan

Thursday, October 15			DAY 2
TIME	SPEAKER	TALK TITLE	CHAIR
09:00–09:50	PLENARY Roland Wiesendanger University of Hamburg	Atomic-Scale Design of Magnet-Superconductor-Hybrids for Realizing Majorana Modes	Yukio Tanaka Nagoya University
09:50–10:15	Stephan Rachel University of Melbourne	Majorana Hybridization, Qubit Errors, and Strategies for Their Suppression	
10:15–10:35	Coffee break		
10:35–11:00	Seishiro Ono ISSP, University of Tokyo	A comprehensive and efficient diagnostic framework for intrinsic topological superconductivity	Akira Furusaki RIKEN
11:00–11:25	Shingo Kobayashi Suwa University of Science	Euler band topology in superfluids and superconductors	
11:25–12:00	Poster Flash Talks — 17 presenters		Ching-Kai Chiu RIKEN iTHEMS
12:00–12:55	Lunch — provided for speakers, organizers, chairs and advisors · Main Research Building (C01), 3F and 4F, east side		
12:55–14:25	Poster Session		
14:25–15:15	PLENARY Daniel Loss University of Basel / KFUPM	TBA	Patrik Recher Technische Universität Braunschweig
15:15–15:40	Thore Posske University of Hamburg	A route to time-reversal symmetric topological superconductors in nonmagnetic adatom systems	
15:40–16:05	Dong Liu Tsinghua University	Vortex Majorana Modes: Interplay, Verification, and Control with Dissipation and Charge Order	
16:05–16:25	Coffee break		
16:25–16:50	Quan-Xin Hu Xiamen University	Towards Tunable Majorana Modes in Iron-Based Superconductors	Dong Liu Tsinghua University
16:50–17:15	Xin Liu Shanghai Jiao Tong University	A strong coupling route for robust Majorana platform	
17:15–17:40	Xiao Hu Shanghai University	Floquet Parity States Based on Majorana Zero Modes	
18:00	Dinner banquet — Administrative Headquarters (C00), 2F · Group photo		

Click a title to jump to its abstract. TBA: title not yet announced.

Majorana Modes: Fundamentals, Status & Directions

PROGRAM

14–16 October 2026 | Okochi Hall, RIKEN Wako Campus, Japan

Friday, October 16				DAY 3
TIME	SPEAKER	TALK TITLE	CHAIR	
09:00–09:50	PLENARY Roman M. Lutchyn Microsoft	Quantum Computation using Majorana-Based Topological Qubits	Thore Posske University of Hamburg	
09:50–10:15	Yukio Tanaka Nagoya University	Theory of Anomalous Proximity Effect by odd-frequency pairing in Topological superconductors	Xin Liu Shanghai Jiao Tong University	
10:15–10:35	Coffee break			
10:35–11:00	Takeshi Mizushima Osaka Metropolitan University	Majorana Ising Spin as a Probe of Pairing Symmetry in UTe ₂	Xin Liu Shanghai Jiao Tong University	
11:00–11:25	Yuichi Kasahara Kyushu University	Quantized thermal Hall effect in the Kitaev magnet α-RuCl ₃	Gábor Halász Oak Ridge National Laboratory	
11:25–11:50	Kenichiro Hashimoto Kyoto University	Specific heat and thermal transport in cobalt-based Kitaev candidates		
11:50–13:00	Lunch — not provided · We suggest the RIKEN main cafeteria (C61); pay by credit card or IC card			
13:00–13:50	PLENARY Fan Zhang The University of Texas at Dallas	Charge Rhombohedral Graphene into Majorana Crystal	Masatoshi Sato YITP, Kyoto University	
13:50–14:15	Yong Chen Tohoku University	Transport Experiments on Candidate Majorana Materials		
14:15–14:35	Coffee break			
14:35–15:00	Ke He Tsinghua University	Build planar PbTe-Pb nanowire devices for topological quantum computing with selective-area molecular beam epitaxy	Tadashi Machida RIKEN CEMS	
15:00–15:25	Lingyuan Kong Westlake University	Topological Iron-Based Superconducting Devices: from Vortex Majorana to emergent Pair Density Modulation		
15:25–15:50	Takami Tohyama Tokyo University of Science	Topological superconductivity in two-dimensional quasicrystals	Seishiro Ono ISSP, University of Tokyo	
15:50–16:15	Ching-Kai Chiu RIKEN iTHEMS	Majorana Kramers Pairs in 2D Weyl Heterostructures and probe the Majorana Z ₂ feature		
16:15–16:35	Coffee break			
16:35–17:00	Masatoshi Sato Yukawa Institute for Theoretical Physics, Kyoto University	Non-Hermitian perspectives on Majorana fermions	Fuchun Zhang Kavli ITS, UCAS	
17:00–17:25	Motohiko Ezawa The University of Tokyo	Topological superconductors and Majorana fermions based on X-wave magnets with X=p,d,f,g,i		
17:25–17:50	Patrik Recher Technische Universität Braunschweig	Transport through coupled Majorana bound states in the presence of parity switching poisoning events		
17:50–18:00	Naoto Nagaosa RIKEN CEMS and FQSP	Closing Remarks		

Click a title to jump to its abstract. TBA: title not yet announced.

TALK ABSTRACTS

Wednesday, October 14

DAY 1

WEDNESDAY · 09:10–10:00 · PLENARY

Jay D. Sau

University of Maryland

Theorist's perspective on topological qubits in semiconductor nanowires: progress and challenges

Spin orbit coupled semiconductor nanowires in proximity to a superconductor and in a magnetic field have been proposed as a route to Majorana zero modes and ultimately topological qubits. Following a short review of the theory of Majorana zero modes in one dimensional topological superconductors, I will discuss the various alternative candidates for zero-modes as well as the obstacles faced in the first decade of the field. Over the past decade Microsoft Q has made significant progress in terms of device architecture, non-local transport measurements as well as qubit parity measurements. More recently the Delft group has made similar advances in a quantum dot chain platform and has provided coherence measurements for a Majorana qubit. Non-local transport measurements are a powerful tool to identify the topological phase transition. In this context I will discuss the challenges of identifying topological phases in short disordered systems as well as the significance of radio-frequency measurements of flux dependent capacitance in terms of identifying Majorana modes. I will then discuss ways to demonstrate qubit coherence in terms of the life-times and Rabi oscillations that have been measured as well as measurement based topological gates.

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WEDNESDAY · 10:45–11:10

Robert Peters

Kyoto University

Neural Network Quantum States for Topological Quantum Spin Systems: From the Toric Code to the Kitaev Model

Neural-network quantum states (NQS) provide a flexible variational framework for studying quantum spin liquids and topological states beyond exactly solvable limits. In this talk, I will discuss a physically informed NQS approach that combines neural-network flexibility with known structure of the underlying quantum states.

As a first example, I consider the toric code perturbed by an antiferromagnetic isotropic Heisenberg interaction. Using variational Monte Carlo together with symmetry-adapted NQS, we follow the ground state from the exactly solvable point through the breakdown of topological order. At weak coupling, the numerical results agree with a Schrieffer–Wolff description, which also explains the perturbative stability of the topological sectors: local processes dress the ground-state manifold, while mixing different topological sectors requires system-spanning virtual processes. At stronger coupling, the topological phase gives way to a fourfold antiferromagnetic Néel state.

I will then discuss recent work on the Kitaev honeycomb model. Here, direct optimization in the full spin basis is challenging because the plaquette-flux structure is difficult to learn variationally. By incorporating the known plaquette structure into the representation, the optimization is substantially improved. I will conclude with an outlook toward perturbed Kitaev systems, where the aim is to retain useful information from the solvable point while allowing the neural state to learn the deformation away from it.

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WEDNESDAY · 11:10–11:35

Shu Zhang

Okinawa Institute of Science and Technology

Sensing and steering mobile topological defects in two dimensions

Topological defects, such as vortices in planar magnets and superconductors, are particle-like objects, whose proliferation and motion govern both phase transitions and transport properties in two-dimensional matter. The main part of the talk will discuss magnetic noise spectroscopy as a probe of magnetic Berezinskii–Kosterlitz–Thouless physics [1]. Below the transition, algebraic spin correlations generate a temperature-dependent power-law noise spectrum. Above it, free vortices form a plasma that overdamps spin waves, and fitting the noise spectrum yields the vortex conductivity. I will also briefly talk about the injection of topological defects into the bulk by biasing the edge modes of topological matter [2]. In particular, the thermally biased Majorana edge of a topological superconductor injects vortices at a rate set by the universal fractional entropy of the Majorana zero modes.

REFERENCES

- [1] M. Potts and S. Zhang, Nano Lett. 25, 17677 (2025).
 [2] M. Tanhayi Ahari, S. Zhang, J. Zou, and Y. Tserkovnyak, Phys. Rev. B 104, L201401 (2021).

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WEDNESDAY · 12:50–13:15

Kumpei Imamura

Kyoto University

Thermodynamic signatures of Majorana excitations in the Kitaev magnet α -RuCl₃

The Kitaev honeycomb model provides a paradigmatic example of quantum fractionalization, where spin-1/2 moments fractionalize into itinerant Majorana fermions and localized flux excitations. Under a magnetic field, the model is expected to enter a topological quantum spin liquid phase with chiral Majorana edge modes and non-Abelian quasiparticles. The honeycomb magnet α -RuCl₃ has emerged as a leading candidate for realizing the Kitaev quantum spin liquid (KQSL) in a real material. In the field-induced disordered phase, several experimental signatures suggestive of fractionalized excitations have been reported. In particular, the half-integer quantization of the thermal Hall conductance has attracted considerable attention as possible evidence for chiral Majorana edge transport. However, the interpretation of these observations remains under debate, partly because of pronounced sample dependence.

In this talk, I will present field-angle-resolved specific heat measurements of α -RuCl₃ as a bulk probe of the low-energy excitation spectrum. In high-quality single crystals, we observe a pronounced sixfold oscillation of the low-temperature specific heat in the field-induced disordered regime. This angular structure, including gapless behavior for fields along the crystallographic b axis, is consistent with the characteristic anisotropy expected for itinerant Majorana excitations in the KQSL. We further show that the same behavior is preserved in ultraclean samples with exceptionally sharp magnetic transitions, demonstrating that these thermodynamic signatures are intrinsic to α -RuCl₃ rather than arising from sample imperfections. Finally, I will discuss our recent high-field measurements up to 24 T, which reveal how the KQSL regime evolves and eventually crosses over toward a more conventional polarized state.

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WEDNESDAY · 13:15–13:40

Eun-Gook Moon

KAIST

Identification of a Kitaev Quantum Spin Liquid

Quantum spin liquids host fractionalized excitations and quantum entanglement beyond the conventional symmetry-breaking paradigm. The Kitaev model provides a particularly striking example, supporting Majorana fermions and emergent gauge fields, but their unambiguous identification in real materials remains challenging. In strongly spin-orbit-coupled magnets, gapless excitations are generally fragile and can occur only under rather restrictive conditions. It is therefore particularly remarkable that, in the Kitaev system, the symmetry of Majorana fermions on the honeycomb lattice can control whether the excitation spectrum is gapless or gapped. In this talk, I will discuss how lattice symmetries constrain the Majorana gap structure under a magnetic field and lead to distinctive field-angle-dependent signatures. I will connect these symmetry-controlled gap structures to thermodynamic measurements and planar thermal Hall responses in α -RuCl₃. Such a symmetry-based manipulation between gapless and gapped Majorana excitations, together with their experimental consequences, provides a characteristic route toward identifying fractionalization beyond conventional magnon physics.

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WEDNESDAY · 13:40–14:05

Gábor Halász

Oak Ridge National Laboratory

Geometric probes of chiral Majorana edge modes in Kitaev spin liquids

Majorana zero modes attached to non-Abelian anyons in Kitaev spin liquids provide a viable avenue to topological quantum computation at elevated temperatures. These Majorana zero modes are in turn intimately connected to chiral Majorana edge modes that are predicted to produce a half-integer-quantized thermal Hall effect. Nevertheless, recent thermal-transport experiments on the Kitaev magnet α -RuCl₃ highlight the challenge in identifying such chiral Majorana edge modes by relying on the quantization of the thermal Hall effect alone. Here, we theoretically propose and experimentally demonstrate that the origin of the thermal Hall effect can be determined by varying the underlying sample geometry through, for example, introducing constrictions. By studying standard phenomenological heat-transport equations based on minimal assumptions, we show that, whereas a conventional thermal Hall effect due to phonons or magnons is completely geometry independent, a thermal Hall effect originating from a chiral Majorana edge mode is significantly enhanced by geometric constrictions at low temperatures. Motivated by this result, we measure the thermal Hall effect in both constricted and unconstricted samples of α -RuCl₃; the comparison of these two measurements reveals a pronounced geometry dependence of the thermal Hall effect and thus provides compelling evidence of a chiral Majorana edge mode associated with a non-Abelian Kitaev spin liquid.

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WEDNESDAY · 14:05–14:30

Dmitri Feldman

Brown University

Interferometry revisited

Anyonic interferometry is a key probe of fractional statistics. Its Fabry-Perot version has recently been successfully implemented in the simplest fractional quantum Hall states decades after a theoretical proposal. Such delay is explained by two challenges for interferometry. First, universal statistical phases are intertwined with non-universal Coulomb effects. Second, Fabry-Perot interferometry data allow a straightforward interpretation at low visibility only. Besides, standard interferometry schemes are unsuitable to probe neutral

anyons such as quasiparticles in Kitaev magnets. We propose two approaches, which mitigate these issues. First, we introduce interferometry on co-propagating edge channels of a single edge such as the edge of the $-3/5$ state in twisted molybdenum telluride bilayers. This setup does not allow anyons to make multiple loops around the device and hence can be interpreted straightforwardly for any interchannel tunneling. The geometry also reduces Coulomb effects. Interestingly, a simple exact solution is available for the current and noise at multiple filling factors. This setup has already inspired new experiments. Second, we introduce thermal interferometry suitable for both charged and neutral anyons, such as non-Abelian anyons in Kitaev liquids. In contrast to the interferometry of charged anyons, it is essential to compare thermal signals in two different interferometer geometries.

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WEDNESDAY · 14:50–15:15

Can-Li Song

Tsinghua University

Majorana zero modes and their interplay with charge stripes in iron-pnictide films

Majorana zero modes (MZMs) in topological superconductors provide a promising platform for exploring non-Abelian quasiparticles and topological quantum computation. Iron-based superconductors have emerged as an attractive setting for realizing MZMs within magnetic vortices, where high-temperature superconductivity and nontrivial band topology can coexist intrinsically. Here, we report spectroscopic evidence for MZMs in vortices of superconducting $\text{BaFe}_{0.94}\text{Co}_{0.06}\text{As}_2$ films and reveal their intriguing interplay with an underlying charge-stripe order. High-resolution scanning tunneling spectroscopy resolve two distinct types of vortex bound states with and without MZMs, which are found to be spatially correlated with the charge stripes: Majorana vortices preferentially occur near stripe nodes, whereas ordinary vortices tend to appear near stripe antinodes. These observations reveal an intimate connection between electronic correlation and topological vortex states, suggesting charge order as a potential route for manipulating Majorana physics in iron-based superconductors.

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WEDNESDAY · 15:15–15:40

Tong Zhang

Fudan University

Observation of sharp and magnetic-field tunable zero-energy states in $\text{MnTe}/\text{Bi}_2\text{Te}_3/\text{NbSe}_2$ heterostructure

Abstract to be announced.

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WEDNESDAY · 15:40–16:05

Hao Zheng

Shanghai Jiao Tong University

Gating the Yu-Shiba-Rusinov states in Bi_2Te_3 / NbSe_2 heterostructures by a scanning tunneling microscope tip

Fe dopants on the surface of a topological insulator Bi_2Te_3 thin film grown on a superconducting NbSe_2 substrate by molecular beam epitaxy are investigated by a dilution-refrigerator scanning tunneling microscope. Utilizing the tip-induced band bending effect, we precisely manipulate the dopant's energy level and charge state. When the dopant level is tuned near the superconducting gap, the system reaches the mixed valence regime. Yu-Shiba-Rusinov states emerge, shift continuously, and cross zero energy as the dopant level is tuned, all of which are reproduced by our multi-orbital Anderson-Kanamori model simulations. Unlike conventional exchange-coupling-

driven transitions of Yu-Shiba-Rusinov states where Kondo screening dominates, the mechanism here is governed by dopant-level-driven charge transfer and resonantly enhanced Kanamori interactions. These findings open a new avenue to quantum state engineering and spin-dependent transport in semiconductor/superconductor hybrid systems.

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WEDNESDAY · 16:25–16:50

Kam Tuen Law

The Hong Kong University of Science and Technology

Quantum Anomalous Hall Insulator-based Majorana platforms

Abstract to be announced.

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WEDNESDAY · 16:50–17:15

Sadashige Matsuo

Institute of Science Tokyo

Control and detection of Andreev states via the wavefunction leakage

Hybrid systems of superconductors and semiconductors have attracted considerable attention as a promising platform for realizing topological superconductivity and Majorana zero modes. In particular, planar Josephson junctions offer a versatile platform in which superconducting properties can be controlled by electrostatic gating and superconducting phase differences [1]. The low-energy electronic properties of these junctions are governed by Andreev bound states (ABSs). Although ABSs are primarily localized in the normal regions of Josephson junctions, their wave functions extend into the superconducting electrodes over the coherence length. This wave-function leakage provides opportunities for both engineering coherent coupling between ABSs and developing new spectroscopic techniques.

In this talk, I will present two experimental studies utilizing the wave-function leakage of ABSs in Josephson junctions fabricated on InAs quantum wells covered with epitaxial aluminum. First, we investigate two Josephson junctions coupled through a short superconducting electrode. Tunnel spectroscopy reveals that the ABS spectra are strongly modified by coupling the two junctions, and similar spectral features are observed in both junctions. These results, together with numerical calculations, demonstrate the formation of phase-dependent Andreev molecules arising from the hybridization of ABSs [2]. Second, we demonstrate remote tunnel spectroscopy of ABSs through a superconducting electrode. By attaching a tunnel probe to the superconducting electrode away from the junction, we successfully detect phase-dependent ABS spectra. The observed spectra are electrically tunable and are well explained by the short ballistic Josephson junction model. These findings establish wave-function leakage as a useful mechanism for controlling and detecting ABSs and provide a basis for investigating bulk and edge states in planar Josephson junctions toward Majorana physics.

REFERENCES

- [1] H. Ren et al., Nature **569**, 93 (2019); A. Fornieri et al., Nature **569**, 89 (2019).
- [2] S. Matsuo et al., Nature Communications **14**, 8271 (2023).

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WEDNESDAY · 17:15–17:40

Jelena Klinovaja

University of Basel

Properties and prevalence of false poor man's Majoranas in two- and three-site artificial Kitaev chains

A minimal chain of two quantum dots (QDs) connected via a superconductor has been predicted to host perfectly localized zero-energy states, known as poor man's Majoranas (PMMs). These states are expected to be related to Majorana bound states (MBSs) in longer chains and that the tunable nature of this setup makes it a promising platform to study MBSs. However, realistic systems can only host highly, but not perfectly, localized near-zero-energy states, called imperfect PMMs. These imperfect PMMs have been shown to evolve into trivial states unrelated to MBSs when the chain is extended. Such states are called false PMMs, whereas PMMs that evolve into MBSs in long chains are called true PMMs. Here, using a microscopic model of QD-superconductor arrays, we consider properties of false PMMs and the circumstances under which they appear. In two-site systems, we find that the origin of many false PMMs can be related to zero-energy states occurring in the absence of superconductivity, and we use this analytic understanding to characterize the false PMMs that are typical for different regions of parameter space. In three-site systems, we show that false PMMs can occur via the same mechanism as for two-site systems, but we also find them in regions of parameter space where they are not predicted to exist, thus hinting that the physics of false PMMs can be richer in longer chains. Finally, we demonstrate that the PMMs most stable to perturbations in chemical potential and with the largest excitation gaps appear in a region of parameter space that also has a large ratio of false to true PMMs.

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TALK ABSTRACTS

Thursday, October 15

DAY 2

THURSDAY · 09:00–09:50 · PLENARY

Roland Wiesendanger

University of Hamburg

Atomic-Scale Design of Magnet-Superconductor-Hybrids for Realizing Majorana Modes

In the past ten years, we made use of STM-based single atom manipulation techniques in order to fabricate defect-free magnetic adatom chains on s-wave superconductors with high spin-orbit coupling [1-3] and to study the emergence of zero-energy modes as entangled quantum states at both ends as a function of chain length. In particular, we could unambiguously reveal chain-length dependent oscillations of the low-energy modes simultaneously probed by STS at both ends [3] which have been theoretically identified early on as a smoking gun for the experimental confirmation of Majorana modes [4,5]. By applying Bogoliubov quasiparticle interference (QPI) mapping to the defect-free 1D magnet-superconductor hybrid systems, we could directly probe the topologically non-trivial band structure as well as determine a topological gap size as large as 0.18 meV [2]. By taking the multi-orbital nature of the Shiba bands into account, we were able to demonstrate that emerging topological phases can exhibit Majorana zero modes with an unconventional spatial appearance [6], ranging from ‘side features’ [2] to ‘double-eye’ features at the chain ends [7]. Recently, we studied Majorana zero modes in well-defined spin-chains constructed atom-by-atom on artificially designed heterostructures involving Rashba alloy films with large spin-orbit coupling and proximity-induced superconductivity from a niobium substrate [8]. Despite considerable nano-scale disorder present in these heterostructures, we show both experimentally and theoretically that the Majorana modes are robust against such potential disorder. This seems to be a characteristic property of magnet – superconductor hybrids which appear less sensitive to disorder compared to the semiconducting nanowire platform [9,10].

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- [1] H. Kim et al., Science Advances 4, eaar5251 (2018).
- [2] L. Schneider et al., Nature Physics 17, 943 (2021).
- [3] L. Schneider et al., Nature Nanotechnol. 17, 384 (2022).
- [4] S. Das Sarma et al., Phys. Rev. B 86, 220506(R) (2012).
- [5] T. D. Stanescu et al., Phys. Rev. B 87, 094518 (2013).
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THURSDAY · 09:50–10:15

Stephan Rachel

University of Melbourne

Majorana Hybridization, Qubit Errors, and Strategies for Their Suppression

Braiding Majorana zero modes (MZMs) provides a promising route toward quantum information processing. An almost unavoidable challenge in such protocols is the overlap of Majorana wave functions, known as Majorana hybridization, which occurs whenever Majorana modes approach one another. This hybridization lifts the ground-state degeneracy and can lead to errors during the braiding process.

In this talk, I will first analyse in detail how qubit errors arise from dynamically induced Majorana hybridization [1]. I will then introduce a symmetry-enforced strategy that can substantially suppress, or even eliminate, hybridization throughout the braiding process [2]. Finally, I will discuss how even weak electron-electron interactions can induce Majorana hybridization and associated qubit errors [3], with particular relevance to the recently proposed quantum-dot platform. I will show that a recalibrated “sweet spot” can mitigate these errors and improve the robustness of interacting Majorana qubits [4].

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THURSDAY · 10:35–11:00

Seishiro Ono

ISSP, University of Tokyo

A comprehensive and efficient diagnostic framework for intrinsic topological superconductivity

Theoretical prediction of topological superconductivity is key to their discovery. However, a comprehensive and efficient method for diagnosing topological superconductivity in realistic materials remains elusive. Here, we derive Fermi-surface formulas for gapped and gapless topological phases of time-reversal symmetric superconductors with s-wave-like pairing symmetries in all layer and space groups, applicable to thin-film and bulk materials. Our diagnosis uses only the sign of the pairing and the Fermi velocity at several Fermi points, and yields complete (partial) diagnosis for gapped and gapless superconducting phases in 159 (71) space groups. This provides a fundamental basis for the first-principles prediction of new topological superconductors.

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THURSDAY · 11:00–11:25

Shingo Kobayashi

Suwa University of Science

Euler band topology in superfluids and superconductors

In systems with space-time symmetries, a distinct type of topological structure known as real band topology can emerge. Real band topology is defined for real-valued wave functions and is characterized by topological invariants such as the Euler and Stiefel–Whitney classes.

In this talk, I will discuss real band topology in superfluids and superconductors. We have formulated real band topology for Bogoliubov–de Gennes Hamiltonians in the presence of space-time symmetries and derived relations between real-band topological invariants and previously known topological invariants [1,2]. Using these relations, we have shown that the B phase of superfluid helium-3 under a magnetic field realizes a topological superfluid characterized by the Euler class, and that superconducting gap nodes characterized by the Euler class can appear in multiorbital spin-singlet superconductors [2]. Recent results further demonstrate that three-dimensional systems with a nontrivial Euler class can host multiple chiral hinge modes [3].

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THURSDAY · 15:15–15:40

Thore Posske

University of Hamburg

A route to time-reversal symmetric topological superconductors in nonmagnetic adatom systems

Filling the periodic table of topological matter with representatives in each class remains an ongoing scientific challenge. Despite candidate materials, the experimental evidence for time-reversal symmetric superconductors (class DIII) remains ambiguous, especially in low-dimensional systems.

We present a route to class DIII topological superconductors by hybridizing Machida-Shibata states, i.e., particle-in-a-box states with proximity-induced superconductivity [1,2]. We elaborate on the role of a no-go theorem for this symmetry class, and demonstrate how electron interactions circumvent it.

If successfully realized, the Machida-Shibata lattices would accommodate Kramers pairs of Majorana modes and helical Majorana channels in 1D and 2D, respectively.

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THURSDAY · 15:40–16:05

Dong Liu

Tsinghua University

Vortex Majorana Modes: Interplay, Verification, and Control with Dissipation and Charge Order

This talk focuses on how vortex Majorana physics is modified by, and can be interrogated through, its coupling to other low-energy degrees of freedom. First, we show that a dissipative scanning-tunneling probe provides a simple additional test of candidate Majorana signals. In SrSn_3 films, increasing the tip-sample coupling drives a zero-bias peak continuously into a dip through dynamical Coulomb blockade, behavior inconsistent with the expected response of a Majorana zero mode. We then turn to charge-density-wave order, where the interplay is stronger and also enables control. The local CDW phase correlates with the appearance of zero modes and, through inversion-symmetry breaking and enhanced singlet-triplet pairing mixing, can drive a vortex across a topological transition. Together, these results show how dissipation and charge order can serve as both diagnostic environments and active knobs for vortex Majorana modes.

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THURSDAY · 16:25–16:50

Quan-Xin Hu

Xiamen University

Towards Tunable Majorana Modes in Iron-Based Superconductors

Iron-based superconductors and their heterostructures offer a promising platform for exploring Majorana zero modes (MZMs) and their potential applications in topological quantum computing. The interplay between superconductivity and electronic topology, together with the tunability of these systems, provides opportunities to control the emergence of MZMs and the number of vortices hosting them. In this talk, I will present our recent progress in tuning MZMs through two complementary approaches: uniaxial stress and island-size control. In

LiFeAs, we demonstrate control over the emergence and disappearance of MZMs by applying uniaxial stress along the [110] and [100] crystallographic directions, highlighting mechanical stress as an effective tuning parameter for Majorana states. Furthermore, in FeTe/Bi₂Te₃ islands grown by molecular beam epitaxy, we tune the number of vortices hosting MZMs by controlling the island size, extending Majorana control to confined superconducting structures. Together, these results establish mechanical and geometric tuning as complementary routes toward controllable Majorana platforms and provide a foundation for future exploration of Majorana-based quantum computation.

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THURSDAY · 16:50–17:15

Xin Liu

Shanghai Jiao Tong University

A strong coupling route for robust Majorana platform

Realizing robust Majorana zero modes (MZMs) in hybrid structures requires balancing superconducting proximity against interfacial band renormalization. In conventional hybrid platforms, stronger interface coupling hardens the proximity gap but also enhances interfacial band renormalization and narrows the topological window; MZMs are therefore typically sought only in weak- or intermediate-coupling regimes. In this talk, I will present a generic mechanism based on a Meissner-induced inhomogeneous Doppler response that stabilizes the topological phase transition across a broad coupling range, including the strong-coupling regime. In a partially superconducting-covered topological-insulator nanowire, this inhomogeneity produces a spatial separation between two roles: the SC/TI interface remains the strongly proximitized hard-gap sector, while the gate-tunable bottom surface becomes the transition-driving sector where a flux-driven topological phase transition occurs. Using a multiscale framework that combines supercurrent simulations, self-consistent Schrödinger-Poisson electrostatics, and large-scale tight-binding calculations, we show that this mechanism survives realistic device conditions: the transition location is only weakly dependent on chemical potential, the reopened topological gap is optimized near the bottom-surface Dirac point, and the resulting Majorana regime remains stable against strong disorder in the tested range.

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THURSDAY · 17:15–17:40

Xiao Hu

Shanghai University

Floquet Parity States Based on Majorana Zero Modes

Majorana zero modes (MZMs) offer a promising route to non-Abelian statistics for fault-tolerant topological quantum computation. In this talk, I will present a theoretical study of Floquet parity states based on MZMs, which can be used to manipulate topological quantum bits. In particular, we show that a DC bias voltage across a Majorana–Josephson junction induces Landau–Zener–Stückelberg interference between parity states composed of MZMs. We also discuss Rabi oscillations of quantum states supported by MZMs. The work is based on collaboration with Zhi Wang, Sun Yat-sen University, China.

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TALK ABSTRACTS

Friday, October 16

DAY 3

FRIDAY · 09:00–09:50 · PLENARY

Roman M. Lutchyn

Microsoft

Quantum Computation using Majorana-Based Topological Qubits

Research in quantum computing has provided numerous new physical insights and the potential to exponentially increase computational power for solving significant problems in science and technology. The primary obstacle to building a scalable quantum computer is errors caused by decoherence. Topological quantum computing addresses this challenge by utilizing topological materials that inherently limit errors. In this talk, I will discuss the engineering of topological superconductors that support Majorana zero-energy modes at the interface between a conventional superconductor (Aluminum or Lead) and a semiconductor with spin-orbit interaction (Indium Arsenide). I will present recent findings from the Microsoft Quantum team that indicate the emergence of topological superconductivity in proximitized semiconductor nanowires. Additionally, I will cover recent measurements of fermion parity, which represent a step towards the fusion and braiding of Majorana zero modes. Finally, I will outline a proposal for scalable quantum computing that involves topological qubits composed of superconducting islands in a Coulomb blockade regime, hosting aggregates of four or more Majorana zero modes.

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FRIDAY · 09:50–10:15

Yukio Tanaka

Nagoya University

Theory of Anomalous Proximity Effect by odd-frequency pairing in Topological superconductors

Odd-frequency pairing is known to appear ubiquitously in superconductor junctions [1–2], and its amplitude is strongly enhanced at edges or interfaces when zero-energy surface Andreev bound states (ZESABS) or Majorana zero modes (MZMs) are present [2–3]. One of the most remarkable consequences of odd-frequency spin-triplet (s)-wave pairing is the anomalous proximity effect in diffusive normal-metal (DN) / spin-triplet (p)-wave superconductor junctions, where the quasiparticle density of states in the DN exhibits a pronounced zero-energy peak (ZEP) in the local density of states due to the penetration of odd-frequency spin-triplet (s)-wave pairs [4,5]. The remarkable property is the quantization of conductance if we consider a 1d or 2d junctions with flat band ZESABS or MZM, the zero voltage conductance is quantized [4,6].

Regarding the experimental verification of this anomalous proximity effect, our theoretical prediction was confirmed in tunneling measurements on $\text{CoSi}_2/\text{TiSi}_2$ heterojunctions [6]. We also note that the anomalous proximity effect can occur in Rashba superconductors realized in nanowires placed on the surface of a conventional spin-singlet (s)-wave superconductor with spin-orbit coupling and a Zeeman field [7].

Furthermore, we have clarified that the feature of the energy dependence of odd-frequency pairing can distinguish trivial and topological Andreev zero-energy bound states (Majorana zero mode) in nano-wire system [8]. Recently, we developed boundary conditions describing spin-dependent interfaces between two materials, at least one of which is diffusive. These boundary conditions, formulated using the action formalism starting from non-linear sigma model, yield clean and tractable expressions. Using them, we investigated the anomalous proximity effect in the presence of a magnetic interface and elucidated the stability of the ZEP associated with odd-frequency pairing [9].

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FRIDAY · 10:35–11:00

Takeshi Mizushima

Osaka Metropolitan University

Majorana Ising Spin as a Probe of Pairing Symmetry in UTe_2

Majorana fermions have attracted considerable interest as objects to detect and manipulate. In this talk, I will explore a complementary perspective: using their intrinsic properties to probe the underlying superconducting order parameter. A key example is the Majorana Ising spin, a symmetry-dependent magnetic response [1,2]. In the candidate topological superconductor UTe_2 , strong spin-orbit coupling constrains the order parameter, making the Majorana Ising spin a promising fingerprint of pairing symmetry. I will show that the anomalous proximity effect, mediated by odd-frequency pairing, can substantially enhance the Majorana spin signal in a diffusive metal coupled to UTe_2 [3]. Our calculations predict a pronounced, pairing-symmetry-dependent anisotropy in the NMR spin-lattice relaxation rate, offering a possible route to identifying the superconducting order via surface Majorana fermions.

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FRIDAY · 11:00–11:25

Yuichi Kasahara

Kyushu University

Quantized thermal Hall effect in the Kitaev magnet $\alpha\text{-RuCl}_3$

Kitaev quantum spin liquid (QSL) displays the fractionalization of quantum spins into Majorana fermions. In magnetic fields, the emergence of Majorana edge current is predicted to manifest itself in the form of half-integer quantized thermal Hall (HIQTH) effect.

Here, we report the observation of the HIQTH effect in $\alpha\text{-RuCl}_3$, a prime candidate material for the Kitaev QSL. Remarkably, the HIQTH effect is observed even when the magnetic field is applied parallel to the in-plane thermal current. The angular dependence of the HIQTH effect exhibits the same sign structure as the topological Chern number predicted for the Kitaev QSL. Furthermore, when the magnetic field is rotated across the b-axis, we observe both a sign reversal of the HIQTH effect and the closing of an energy gap, resulting in the formation of a Dirac cone. These results provide compelling evidence that the observed HIQTH effect originates from Majorana fermions.

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FRIDAY · 11:25–11:50

Kenichiro Hashimoto

Kyoto University

Specific heat and thermal transport in cobalt-based Kitaev candidates

Cobalt-based honeycomb magnets provide a platform for investigating Kitaev physics, but the nature of their field-induced disordered states remains an open question. In this talk, I will present field-angle-resolved specific heat measurements on $\text{Na}_2\text{Co}_2\text{TeO}_6$ and $\text{Na}_3\text{Co}_2\text{SbO}_6$, and discuss their low-energy excitations in connection with thermal transport. In $\text{Na}_2\text{Co}_2\text{TeO}_6$, the high-field specific heat reveals a finite excitation gap for all measured in-plane field directions. Its angular dependence differs from that expected for Majorana excitations in the Kitaev model and supports a magnon-based interpretation of the reported thermal Hall response. In contrast, $\text{Na}_3\text{Co}_2\text{SbO}_6$ exhibits a pronounced sixfold oscillation of the specific heat in the field-induced disordered regime, despite the strong twofold anisotropy of the magnetization. This angular pattern resembles that observed in $\alpha\text{-RuCl}_3$ and is consistent with the expected anisotropy of Majorana excitations. I will also present longitudinal thermal conductivity and thermal Hall measurements on $\text{Na}_3\text{Co}_2\text{SbO}_6$, and discuss their implications for the nature of the magnetic excitations.

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FRIDAY · 13:00–13:50 · PLENARY

Fan Zhang

The University of Texas at Dallas

Charge Rhombohedral Graphene into Majorana Crystal

Recent experimental breakthroughs have established rhombohedral graphene (RG), a strongly correlated, topologically nontrivial, electronic system theoretically proposed 16 years ago [1, 2], as a novel and highly tunable platform for exploring superconductivity, magnetism, topology, and fractionalization within a single material system [3]. Its properties can be tuned through layer thickness, carrier density, electric and magnetic fields, as well as engineered moiré potentials and spin-orbit coupling. In this talk, I will first introduce RG and chart its phase diagram established to date. Next, I will discuss an unexpected experimental discovery in RG [4] – intra-K-valley superconductivity – and recent theoretical advances. We will show that one superconducting state originates from a single-spin, single-valley, single-band, single-Fermi-pocket parent state and is most likely a chiral topological pair-density wave [5]. This phase hosts Majorana zero modes, anomalous superconducting diode effect, and an extraordinary gauge structure. Equivalently, this phase can be viewed as a chiral topological superconductor on a triangular lattice together with a Majorana crystal on its dual honeycomb lattice [6]. These findings propose a route toward non-Abelian anyon crystals.

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FRIDAY · 13:50–14:15

Yong Chen

Tohoku University

Transport Experiments on Candidate Majorana Materials

We present our recent experimental studies – including both device-based quantum transport and STM-based local probe transport – on several candidate materials platforms predicted to host charge or spin-based Majorana modes, including candidate topological superconductors (TSC) predicted to exist in topological insulator (TI)/superconductor (SC) interfaces and in “innate” (candidate) TSC Fe(Te,Se), and candidate Kitaev spin-liquid (KSL) material RuCl₃. Measurements on SC/TI/SC Josephson junctions using state of the art bulk-insulating TI material (BiSbTeSe₂ we developed) [1] reveal various anomalous signature different from conventional SNS Josephson junctions [2–4], suggesting supercurrent flowing via topological surface state with “topological protection” leading to highly non-sinusoidal current-phase-relation (CPR) indicative of ballistic junction behavior. We also discuss a possible observation of zero-bias-peak in a SC “antidot” formed on TI surface via scanning tunneling spectroscopy (STS) measurements. STS on Fe(Te,Se) confirm the observation of zero-bias peak (attributed to Majorana zero mode in previous experiments) associated with adatoms and impurities at zero magnetic field, while transport measurements reveal an interesting magnetic field-free superconducting diode effect. Finally, spin-sensitive transport measurements on RuCl₃/Pt heterostructures reveal an angular magnetoresistance oscillation attributed to spin-Hall magneto-resistance (SMR), which is used to determine the magnetic moment directions in RuCl₃ and reveals that the spins in RuCl₃ [5] chose a quantization axis transverse to the external in-plane field (even without the need of any magnetic order) in a wide range of the magnetic fields [6], at odds with the usual QSL picture.

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FRIDAY · 14:35–15:00

Ke He

Tsinghua University

Build planar PbTe-Pb nanowire devices for topological quantum computing with selective-area molecular beam epitaxy

Semiconductor-superconductor hybrid nanowire is a major platform for studying Majorana zero modes (MZMs) and topological quantum computing (TQC). Despite years of efforts, a too high disorder level in hybrid nanowires still considered the central problem in this approach. PbTe-based hybrid nanowires have shown significant potential in overcoming the bottleneck problem of sample defects [1,2]. In this talk, I will introduce the recent research progress on selective-area molecular beam epitaxy-grown planar PbTe-Pb hybrid nanowires [3–7]. The nanowires show ballistic transport properties and quantized Andreev conductance, indicating a rather low disorder level in the samples [3–6]. Robust zero bias peaks have been observed in the hybrid nanowires,

persisting and remaining non-split over sizable ranges in magnetic field and gate voltages [7]. The advantages and problems of the new candidate Majorana nanowire system, as well as the prospective of realizing TQC based on it, will be discussed.

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FRIDAY · 15:00–15:25

Lingyuan Kong

Westlake University

Topological Iron-Based Superconducting Devices: from Vortex Majorana to emergent Pair Density Modulation

Topological iron-based superconductors offer a compelling platform for exploring quantum matter and developing future quantum information technologies, particularly topological quantum computing. The coexistence of intrinsic superconductivity and topological surface states, together with favorable energy scales of electronic bands and superconductivity, provides an attractive setting for investigating exotic quantum states of matter, including vortex Majorana modes. Translating these materials into devices opens new opportunities to uncover emergent physics and establish the experimental capabilities needed for Majorana-based quantum computation. In this talk, I will present our progress in developing Fe(Te,Se) devices compatible with atomic-scale scanning tunneling microscopy, connecting earlier spectroscopic studies of vortex Majorana modes with a broader program of device-based exploration. In thin flakes, we observe an emergent intra-unit-cell pair density modulation, characterized by unequal superconducting gaps on the two Fe sublattices. This finding reveals how reduced dimensionality and symmetry breaking can reshape superconductivity, highlighting these devices as a versatile platform for studying the interplay between electronic structure, nematicity, and superconducting order. I will further discuss the prospects for controllable Majorana devices, including in-situ tuning, measurements of Majorana nonlocality, and future tests of non-Abelian statistics. By bringing microscopic characterization together with device engineering, topological iron-based superconductors provide both a rich setting for fundamental discoveries and a promising foundation for topological qubits and, ultimately, fault-tolerant quantum computation.

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FRIDAY · 15:25–15:50

Takami Tohyama

Tokyo University of Science

Topological superconductivity in two-dimensional quasicrystals

The recent discovery of exotic phases in quasicrystals, including quantum criticality, superconductivity, and magnetism, has stimulated renewed interest in the role of aperiodicity in the emergence of these phenomena. The Penrose and Ammann-Beenker tilings are prototypical bipartite two-dimensional quasicrystals that can theoretically host various topological phases when described by a tight-binding model with electron hopping along the tiles and appropriate additional interactions. We find that topological s-wave superconductivity emerges upon introducing Rashba spin-orbit coupling and a Zeeman field into the tight-binding model [1,2]. Furthermore, we confirm the emergence of Majorana zero modes both at vortex cores and along the system

edges. Building on these findings, we demonstrate the existence of quasicrystalline Weyl superconductivity by extending the concept of Weyl superconductivity to periodically stacked two-dimensional superconducting Penrose and Ammann-Beenker tilings [3]. When the chemical potential is located at or near half-filling, we find that superconductivity becomes gapless in the presence of a magnetic field. In addition, when Rashba spin-orbit coupling is present, the resulting quasicrystalline gapless superconductor can acquire a nontrivial topological character [4]. We show that confined states, which appear in the density of states as massively degenerate modes, play a crucial role in the emergence of this gapless (topological) superconductivity.

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FRIDAY · 15:50–16:15

Ching-Kai Chiu

RIKEN iTHEMS

Majorana Kramers Pairs in 2D Weyl Heterostructures and probe the Majorana Z_2 feature

Class-D Majoranas require broken time-reversal symmetry, whereas Majorana Kramers pairs in class DIII form a distinct species realizable without magnetic fields. In a 2D Weyl semimetal/d-wave superconductor heterostructure, the energy asymmetry of the helical edge bands allows Majorana corner modes to be tuned by gate voltages, enabling adiabatic relocation and exchange of time-reversal-symmetric pairs.

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FRIDAY · 16:35–17:00

Masatoshi Sato

Yukawa Institute for Theoretical Physics, Kyoto University

Non-Hermitian perspectives on Majorana fermions

Recent progress in topological phases has shown that topological boundary states of topological insulators and superconductors exhibit hidden non-Hermiticity, revealing an equivalence between Hermitian and non-Hermitian topological phases. In this talk, I will explain the hidden non-Hermiticity of topological boundary states and its implications for Majorana physics.

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FRIDAY · 17:00–17:25

Motohiko Ezawa

The University of Tokyo

Topological superconductors and Majorana fermions based on X-wave magnets with $X=p,d,f,g,i$

We study superconductors coupled with X-wave magnets with $X=p,d,f,g,i$. They are essentially different between altermagnets with $X=d,g,i$ and odd-parity magnets $X=p,f$ due to the compatibility of the spin-singlet formation of the s-wave superconductor. The altermagnets and odd-parity magnets show rich superconducting phase diagrams depending on the strength of the magnetic order, the chemical potential and the ratio of the on-site and nearest-neighbor interactions. Especially, we find that the altermagnetic order stabilizes the chiral p-wave superconductor, which is a class-D topological superconductor hosting Majorana chiral edge states. It is

characterized by the Chern number. Especially, there emerge two chiral edge modes in the i-wave altermagnet, which are characterized by the Chern number 2. On the other hand, the p (f)-wave odd-parity magnetic order stabilizes the p (f)-wave topological superconductor, which is a class-DIII topological superconductor hosting Majorana flat bands. It is characterized by the winding number. Majorana flat bands are robust in the presence of the mixing with the s-wave superconductivity, which is inevitable for odd-parity magnets although the magnitude of the mixing is tiny.

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FRIDAY · 17:25–17:50

Patrik Recher

Technische Universität Braunschweig

Transport through coupled Majorana bound states in the presence of parity switching poisoning events

Topological qubits based on pairs of non-Abelian Majorana bound states (MBSs) are protected by parity which is challenged by quasiparticle poisoning (QPP).

First, we show how QPP affects transport through a pair of coupled MBSs weakly connected to two current leads, using an open system approach and full counting statistics. We find that QPP causes super-Poissonian local shot noise with a Fano factor that diverges with decreasing bias voltage, while the current and the non-local (cross-)noise are only marginally affected. We explain that these features are a direct consequence of the nature of MBSs which become qualitatively different when including nonlocal tunnel-couplings connecting each lead to both MBSs [1]. The latter case would mimic the coupling of current leads to a usual Andreev bound state (ABS). Our findings suggest that shot noise acts as a viable tool to search for MBSs in the presence of QPP.

Second, we propose and analyze a new scheme to observe the characteristic fractional Josephson effect in a time reversal invariant setting using the helical edge states of the quantum spin Hall effect with the quasiparticle continuum touching the spectrum of the ABSs. This is achieved by hybridization of inner- and outer-ABSs effectively detaching the 4π -periodic ABSs formed by two pairs of MBSs from the quasiparticle continuum [2]. We analyze the resulting Shapiro steps and show that the fractional Josephson effect can be observed even when dynamical transitions between the ABSs and the quasiparticle continuum are present.

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