Spectroscopies in Novel Superconductors 2026

August 24 – 28, 2026

Santa Fe, NM USA

Program Overview

Block	Time	Monday August 24, 2026	Tuesday August 25, 2026	Wednesday August 26, 2026	Thursday August 27, 2026	Friday August 28, 2026
	7:30	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
	8:30	Welcome Address *Mark Chadwick*				
	8:45	Opening *Jianxin Zhu*				
		Plenary 1 Chair: Arun Bansil	Plenary 3 Chair: Qimiao Si	Plenary 5 Chair: Joe Thompson	Plenary 6 Chair: *TBD*	Plenary 8 Chair: Mun Chan
9:00-10:30	9:00	*Dmitri Basov*	*Donghui Lu*	*Jeff Sonier*	*Chunhui Du*	*Stuart Brown*
	9:35	*Qimiao Si*	*Adriana Moreo*	*Andreas Kreisel*	*Stevan Nadg-Perge*	*Hari Padma*
	10:10	*Jiarui Li*	*Christine Au-Yeung*	*Suguru Hosoi*	*Ruoxi Zhang*	*Benedikt Fauseweh*
	10:30	Break / Refreshment	Break / Refreshment	Break / Refreshment	Break / Refreshment	Break / Refreshment
11:00-12:30	11:00	*Neil Harrison*	*Sergey Borisenko*	*Eduardo H. da Silva Neto*	*Atsushi Fujimori*	*Stephen Wilson*
	11:35	*Rina Tazai*	*Russell Hemley*	*Girsh Blumberg*	*Takashi Imai*	*Pavel Volkov*
	12:10	*Wooin Yang*	*Rubi Km*	*Xueshi Gao*	*Chung-Hou Chung*	*Wonjune Choi*
	12:30	Lunch	Lunch	Lunch	Lunch	Closing *Jianxin Zhu*
	12:50					
	14:00			Excursion / Free Time		
		Plenary 2 Chair: Adriana Moreo	Plenary 4 Chair: Ludi Miao		Plenary 7 Chair: Eduardo da Silva Neto	
14:30-16:00	14:30	*Elena Bascones*	*Tetsuo Hanaguri*		*Pyongjie Park*	
	15:05	*Nicholas Curro*	*Lu Chen*		*Tuson Park*	
	15:40	*Ruiqi Zhang*	*Pedro Vianez*		*Jingyuan Wang*	
	16:00	Break / Refreshment	Break / Refreshment		Break / Refreshment	
16:30-18:00	16:30	*Masatoshi Imada*	Poster Session		*Michael Smidman*	
	17:05	*Suchitra Sebastian*			*Jedediah Pixley*	
	17:40	*Ayanesh Maiti*			*Muntaser Naamneh*	
	18:00					
18:30-20:30	18:30			Conference Banquet		
	19:00					
	19:30					
	20:00					

Talk Details:
Invited Talks: 25 min + 10 min Q&A
Contributed Talks: 15 min + 5 min Q&A

Posters:
Posters should be hung up before the poster session and can remain through Thursday Aug. 27. The poster boards accommodate poster dimensions up to 48 in x 36 in.

Excursion:
During the excursion time there are a few possible options:

- Free time
- Visit Museum Hill
- Visit Bandelier National Monument
- Tour of the National High Magnetic Field Laboratory: Pulsed Field Facility *(LANL Approval Needed)*.

Hotel Floorplan

Hilton
SANTA FE HISTORIC PLAZA

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Monday August 24th 2026

7:30	Breakfast			Canyon
8:30	Welcome Address	Mark Chadwick	Los Alamos National Laboratory	Mesa Ballroom
8:45	Opening and Overview	Jianxin Zhu	Los Alamos National Laboratory	Mesa Ballroom

Plenary 1 Chair: Arun Bansil 9:00 – 12:30, Mesa Ballroom			
9:00	Dmitri Basov	Columbia University	*Cavity-altered Superconductivity*
9:35	Qimiao Si	Rice University	*Orbital-selective Superconductivity: from Ruddlesden–Popper Nickelates to Twisted WSe_2*
10:10	Jiarui Li	Stanford University	*Superconductivity and Spin Density Wave Order in Bilayer Nickelate*
10:30	Break/Refreshment		Canyon
11:00	Neil Harrison	National High Magnetic Field Laboratory: Pulsed Field Facility	*Universal Planckian dissipation in the strange meta state of the cuprates.*
11:35	Rina Tazai	RIKEN	*Orbital-selective Superconductivity: from Ruddlesden–Popper Nickelates to Twisted WSe_2*
12:10	Wooin Yang	University of Tennessee, Knoxville	*Revealing Chiral d-ave Pairing Symmetry in Sn/Si(111) with Tunneling Andreev Reflection*

12:30	Lunch	Canyon

Plenary 2 Chair: Adriana Moreo 14:30 – 18:00, Mesa Ballroom			
14:30	Elena Bascones	Instituto de Ciencia de Materiales de Madrid	*Cascades of Heavy and Light Electrons in Twisted Bilayer Graphene*

15:05	Nicholas Curro	University of California, Davis	*Measurements of Nematic Susceptibility in Iron-based Superconductors via NMR with Dynamic Strain*
15:40	Ruiqi Zhang	Tulane University	*Magnetism-Enhanced Electron–Phonon Coupling in Cuprate and Nickelate Superconductors*
16:00	Break/Refreshment		Canyon
16:30	Masatoshi Imada	Sophia University / University of Tokyo	*Cuprate Superconductors -- View from AI Aided ab initio Studies and Integrated Spectroscopy Analysis*
17:05	Suchitra Sebastian	Cambridge University	*Title TBD*
17:40	Ayanesh Maiti	Max Planck Institute for Chemical Physics of Solids	*Enhanced Specific Heat Anomaly in Clean Overdoped Tl2201*

18:00	Dinner	On own

Tuesday August 25th 2026

7:30	Breakfast	Canyon

Plenary 3 **Chair: Qimiao Si** **9:00 – 12:30, Mesa Ballroom**			
9:00	Donghui Lu	SLAC National Accelerator Laboratory	*Electronic Structure of Compressively Strained Bilayer Nickelate Thin Film*
9:35	Adriana Moreo	University of Tennessee / Oak Ridge National Laboratory	*Theoretical and Computational Overview of High Tc Superconductivity in Nickelates*
10:10	Christine Au-Yeung	University of British Columbia	*Oxygen-centred Planar Orbitals in the Electronic Structure and SDW of Multilayer Nickelates*
10:30	Break/Refreshment		Canyon
11:00	Sergey Borisenko	IFW-Dresden	*ARPES Evidence for Unconventional Topological*

			Superconductivity in the Fermi Arc States of t-$PtBi_2$
11:35	Russell Hemley	University of Illinois Chicago	*Progress in High Tc Superconductivity Under Pressure*
12:10	Rubi Km	National High Magnetic Field Laboratory: Pulsed Field Facility	*High Field Re-entrant Superconductivity in Infinite-layer Nickelates*

12:30	Lunch	Canyon

Plenary 4
Chair: Ludi Miao
14:30 – 16:00, Mesa Ballroom

14:30	Tetsuo Hanaguri	RIKEN	*Twist Engineering of the Superconducting Gap in $NbSe_2$ Monolayers on Graphene*
15:05	Lu Chen	University of Illinois Urbana-Champaign	*Bulk Superconductivity driven by Disorder-Induced Delocalization in 4Hb-$Ta(S_{1-x}Se_x)_2$*
15:40	Pedro Vianez	Los Alamos National Laboratory	*Conventional superconductivity in heavy fermion superconductor $PrOs_4Sb_{12}$*

16:00	Break/Refreshment	Canyon

Poster Session
16:30 - 18:30, Pecos

#1	Ludi Miao	New Mexico State University	*Field-Robust Two-Dimensional Superconductivity in Ultrathin Sr_2RuO_4 Heterostructures*
#2	Inho Lee	Los Alamos National Laboratory	*Tunable Anisotropy of High-Harmonic Generation in $NbOI_2$*
#3	Nathan Valadez	Center of Integrated Nanotechnologies / University of Central Florida	*High-Resolution Time- and Angle-Resolved Photoemission Spectroscopy Capability at CINT User Facility*
#4	Iftakhar Bin Elius	Center of Integrated Nanotechnologies	*DT-ARPES: A Software Package for Analyzing Time- and Angle*

			Resolved Photoemission Spectroscopy.
#5	Andrew Li	University of Michigan, Ann Arbor	*Agentic Workflow for Many-Body Bandgap Optimization*
#6	Elizabeth Krenkel	Los Alamos National Laboratory	*Oxygen Intercalation and Phase Transition in Sr-substituted 214 Ruddledsen-Popper Nickelates*
#7	Wolfgang Simeth	Los Alamos National Laboratory	*Neutron Spectroscopy on the Heavy-Fermion Superconductor* $CePd_2Si_2$
#8	Caitlin Tempelman	Los Alamos National Laboratory	*Nonmagnon Excitations in van der Waals* β-UTe_3
#9	Philip Murgatroyd	Los Alamos National Laboratory	*Termination-dependent charge transfer enhances the Kondo coupling strength in* $CeCoIn_5$
#10	David Haink	DLR e.V.	*Real Space Properties of a Topological Long-Range* p_x+ip_y*-wave Superconductor*
#11	Jefferson Carter	University of Wyoming	*Exploration of Bulk Crystal 2M-*WS_2*, a Topological Superconductor Candidate*
#12	Mun Chan	National High Magnetic Field Laboratory: Pulsed Field Facility	*Observation of the Yamaji Effect in a Cuprate Superconductor*
#13	Ghulam Mohmad	Indian Institute of Science Education and Research (IISER) Mohali	*Role of Local Strain Field in Tip-induced Superconductivity*
#14	Mohd Monish	Indian institute of science education and research (IISER) Mohali	*High Tc Conventional Superconductivity in Cerium Point Contacts*
#15	Xinze Yang	Yale University	*Quasiparticle Interference of Superconductivity and Sublattice Texture in* CsV_3Sb_5

18:00	Dinner	On own

Wednesday August 26th 2026

7:30	Breakfast	Canyon

Plenary 5
Chair: Joe Thompson
9:00 – 12:30, Mesa Ballroom

9:00	Jeff Sonier	Simon Fraser University	*Muon spin rotation studies of the influence of chemical doping and hydrostatic pressure on UTe_2*
9:35	Andreas Kreisel	Uppsala Universitet	*D-vector spectroscopy in triplet superconductors*
10:10	Suguru Hosoi	Los Alamos National Laboratory	*Pseudo Point Nodes in Spin Triplet superconductor UTe_2*
10:30	Break/Refreshment		Canyon
11:00	Eduardo H. da Silva Neto	Yale University	*Pairing Mediated by Nematic Fluctuations in an Iron-based Superconductor*
11:35	Girsh Blumberg	Rutgers University	*Spectroscopy of Helical Caroli–de Gennes–Matricon States in Multiband $FeTe_{1-x}Se_x$ Superconductor*
12:10	Xueshi Gao	The Ohio State University	*Tuning Electronic Interaction in Superconducting Twisted Multilayer Graphene Family*

12:30	Lunch	Canyon

Excursion
14:00 – 18:00

Museum Hill	*On own*
Bandelier National Monument	***Bus Leaves at 14:00***
National High Magnetic Field Laboratory: Pulsed Field Facility	***Bus Leaves at 14:00*** *LANL Approval Needed*

Banquet
18:30 – 20:30, Mesa Ballroom

Dessert Talk	James L. Smith	*Reminiscences on Superconductivity*

Thursday August 27th 2026

7:30	Breakfast	Canyon

Plenary 6
Chair: *TBD*
9:00 – 12:30, Mesa Ballroom

9:00	Chunhui Du	Georgia Institute of Technology	*Quantum Sensing of Superconducting Materials*
9:35	Stevan Nadg-Perge	Caltech	*Resolving Spectral Gaps and Many-Body Resonances in Superconducting Twisted Trilayer Graphene*
10:10	Ruoxi Zhang	University of California, Santa Barbara	*Imaging the Meissner effect and Local Superfluid Stiffness in a Graphene Superconductor*
10:30	Break/Refreshment		Canyon
11:00	Atsushi Fujimori	National Tsing Hua University	*Nodal Metal Versus Hole Pockets and Interlayer Coupling in Multilayer Cuprates*
11:35	Takashi Imai	McMaster University	*Quantum Critical Spin Excitations in LSCO High Tc Cuprates*
12:10	Chung-Hou Chung	National Yang Ming Chiao Tung University	*A Mechanism for Quantum-Critical Planckian Metal Phase in High-Temperature Cuprate Superconductors*

12:30	Lunch	Canyon

Plenary 7
Chair: Eduardo da Silva Neto
14:30 – 18:00, Mesa Ballroom

14:30	Pyongjie Park	Oak Ridge National Laboratory	*Spin Dynamics and Superconductivity in $CeCoIn_5$ from High-Resolution Inelastic Neutron Scattering*
15:05	Tuson Park	Sungkyunkwan University	*Spectroscopic Study of Pseudogap in Ce-based Heavy Fermion Superconductors*

15:40	Jingyuan Wang	Johns Hopkins University	*Reconciling Strange Metal Transport in $CeCoIn_5$ Through the Difference of Effective Masses*
16:00	Break/Refreshment		Canyon
16:30	Michael Smidman	Zhejiang University	*Interplay of Ferromagnetism and Superconductivity in Ce-based Heavy Fermions*
17:05	Jedediah Pixley	Rutgers University	*Twisted Nodal Superconductors*
17:40	Muntaser Naamneh	Ben Gurion University	*Universal Four-Fold Symmetry in Infinite-Layer Nickelates*

18:00	Dinner	On own

Friday August 28th 2026

7:30	Breakfast	Canyon

Plenary 8 Chair: Mun Chan 9:00 – 12:30, Mesa Ballroom			
9:00	Stuart Brown	University of California, Los Angeles	*Antiferromagnetism, Magnetic Fluctuations and the Superconducting State of Sr_2RuO_4*
9:35	Hari Padma	Case Western Reserve University	*Electronic Metastability in a Driven Cuprate Ladder*
10:10	Benedikt Fauseweh	TU Dortmund University	*Collective Excitations and Long-Range Interactions in Superconductors*
10:30	Break/Refreshment		Canyon
11:00	Stephen Wilson	University of California, Santa Barbara	*Kagome Metals as Platforms for Unconventional Superconductivity*
11:35	Pavel Volkov	University of Connecticut	*Probing Unconventional Superconductors and Inducing Topology with Twist*
12:10	Wonjune Choi	Los Alamos National Laboratory	*Measuring Anyonic Exchange Phases Using Two-Dimensional Coherent Spectroscopy*

12:30	Closing Remarks	Jianxin Zhu	Los Alamos National Laboratory	Mesa Ballroom

Abstracts (in alphabetical order)

Christine Ching Au-Yeung, *University of British Columbia*

Oxygen-centred planar orbitals in the electronic structure and SDW of multilayer nickelates

The recent discovery of high-temperature superconductivity in multilayer nickelates has raised fundamental questions about its electronic origins and possible connection to the cuprates. Here, we identify a common electronic phenomenology across multilayer nickelates, including signatures of a doping-dependent incommensurate spin-density-wave instability coherent enough to reconstruct and partially gap the Fermi surface. We achieve this by exploiting the natural polymorphism between bilayer (2222) and alternating monolayer-trilayer (1313) stacking sequences in bulk $La_3Ni_2O_7$ crystals, and combining angle-resolved photoemission spectroscopy (ARPES) with effective tight-binding modelling. Polarization-dependent ARPES further reveals that the first electron-removal states are dominated by oxygen-centred planar orbitals: along the Fermi surface, their symmetry evolves from the d_{3x2-r2} and d_{3y2-r2} character of 3-spin polarons (3SP) to the familiar d_{x2-y2} character of Zhang-Rice singlets (ZRS) in cuprates. Doping, and thus the occupation of these orbitals, controls the Fermi-surface topology and the competition between magnetic and superconducting instabilities. Our results establish a direct correspondence between the low-energy electronic structure of layered nickelates and cuprates, pointing to a common microscopic origin of their unconventional superconductivity despite the multi-orbital character of the nickelates.

C.C Au-Yeung *et al.* Nature Physics **22**, 1087–1093 (2026)

Elena Bascones, *Instituto de Ciencia de Materiales de Madrid*

Cascades of Heavy and Light Electrons in Twisted Bilayer Graphene

The discovery of superconductivity in magic-angle twisted bilayer graphene in TBG opened a new era in superconductivity and quantum materials. Research on TBG uncovered a plethora of correlated states beyond superconductivity with very unconventional properties, which include diverse broken symmetries, strange metal physics and cascades in the spectral weight. The cascades, early observed in STM and inverse compressibility measurements are the most resilient of these correlated states and involve the largest energies. To describe the cascades in TBG we start from a heavy fermion model on the topological flat bands [1]. Using DMFT + Hartree calculations we showed that the cascades constitute the normal state of twisted bilayer graphene and are already present at temperatures above those at which symmetries are spontaneously broken [2]. The interplay between the strong correlations and topology leads to a very unconventional reorganization of the electronic spectrum [2,3], recently confirmed in measurements with the Quantum Twisting Microscope. The cascades involve the formation of local moments and heavy quasiparticles and are characterized by the non-monotonic filling of the itinerant electron with increasing doping [2]. They produce characteristic signatures in many other experimental probes including transport and optical conductivity [3] and are characterized by a non-conventional temperature dependence [4].

[1] E. Bascones and M.J. Calderón, Phys. Rev. B, **102**, 155149 (2020)

[2] A. Datta, M.J. Calderón, A. Camjayi, E. Bascones, Nature Comm **14**, 5036 (2023)

[3] M.J. Calderón, A. Camjayi, A. Datta, E. Bascones, PRB **112**, L041126 (2025)

[4] A. Camjayi, M.J. Calderón, E. Bascones, *in preparation*.

Dmitri Basov, *Columbia University*

Cavity-altered Superconductivity

Is it feasible to alter the ground state properties of a material by engineering its electromagnetic environment? Inspired by theoretical predictions, experimental realizations of such cavity-controlled properties without optical excitation are beginning to emerge. A grand aspiration of cavity quantum materials research is to uncover fundamentally new routes for controlling properties of matter by judiciously tailoring the quantum electromagnetic environment. We devised and implemented a novel platform to realize cavity-altered materials. Single crystals of hyperbolic van der Waals (vdW) compounds provide a resonant electromagnetic environment with enhanced density of photonic states and prominent mode confinement. We interfaced hexagonal boron nitride (hBN) with the molecular superconductor κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br (κ-ET). Meissner effect measurements demonstrate a strongly altered superfluid density at the hBN/κ-ET interface. Our work highlights the potential of dark cavities devoid of external photons for engineering electronic ground state properties of complex quantum materials. Keren *et al.* Nature **650**, 864–868 (2026)

Iftakhar Bin Elius, *Center of Integrated Nanotechnologies*

DT-ARPES: A Software Package for Analyzing Time- and Angle Resolved Photoemission Spectroscopy.

Time- and angle-resolved photoemission spectroscopy (tr-ARPES) employs a pump–probe technique to directly track the ultrafast evolution of electronic band structures, quasiparticle dynamics, and light-induced quantum phenomena. However, the full potential of tr-ARPES is often limited by the enormous volume and complexity of the datasets it generates, spanning multiple time delays, energy, momentum, temperature, and excitation conditions. Consequently, manual analysis is labor-intensive, time-consuming, and susceptible to user bias, limiting high-throughput studies. To address these challenges, we have developed DT-ARPES, a dedicated multiplatform software package at tr-ARPES facility at Center for Integrated Nanotechnologies (CINT) for comprehensive analysis of both static ARPES and tr-ARPES datasets. DT-ARPES provides automated tools to select region of interests and quantify nonequilibrium electronic phenomena, including conduction-band dynamics, transient electronic states, electron–phonon coupling through self-energy analysis, charge-carrier relaxation, Fermi-level shifts, and electronic temperature. The package integrates a broad suite of fitting models, data analysis routines, numerical approximations, denoising methods, and error-correction algorithms into a unified workflow, enabling faster, more reliable, and reproducible analysis for the ARPES and tr-ARPES research communities.

Girsh Blumberg, *Rutgers University*

Spectroscopy of helical Caroli–de Gennes–Matricon states in multiband $FeTe_{1-x}Se_x$ superconductor

The optical Hall spectroscopy extends the dc Hall conductivity measurements into finite frequency range enabling to acquire a host of new information about the carrier dynamics of electronic systems in strongly correlated matters. We employ terahertz Faraday Hall spectroscopy to probe the relaxation dynamics of quantized helical Caroli–de Gennes–Matricon (CdGM) states in epitaxial $FeTe_{1-x}Se_x$ thin films, nodeless multiband superconductors with short coherence lengths in the moderately clean limit. By exploiting polarization-selective optical transitions, we directly resolve the helicity and band origin of the vortex-core quasiparticles. We observe long-lived CdGM resonances with opposite circular polarizations for electron- and hole-like bands. Such chirality resolved spectroscopy of the helical CdGM states enables independent, band-resolved determination of quasiparticle lifetimes, vortex masses, coherence lengths, and upper critical fields, and reveals their systematic evolution with isovalent Te/Se substitution x. The results establish terahertz magneto-optics as a direct probe of helical vortex-core excitations and provide dynamical evidence for confined CdGM states in multiband iron-based superconductors.

Supported by the National Science Foundation (NSF) Grant No. DMR-2105001 and by the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program Grant Agreement No. 885413.

Sergey Borisenko, *IFW-Dresden*

ARPES Evidence for Unconventional Topological Superconductivity in the Fermi Arc States of t-$PtBi_2$

Topological superconductivity is a key ingredient for realizing Majorana fermions, yet intrinsic material platforms remain scarce. Using angle-resolved photoemission spectroscopy (ARPES) [1], we have recently demonstrated that the Weyl semimetal t-PtBi2 hosts superconductivity confined to its topological surface states, the Fermi arcs [2]. This superconductivity is unconventional, with nodal i-wave symmetry and signatures of emergent Majorana modes [3], and can be robustly detected under both laser- and synchrotron-based ARPES conditions [4]. Moreover, t-PtBi2 fulfills the canonical criteria favorable for high-Tc superconductivity, opening the door to tuning and optimizing this exotic state [5]. These findings establish t-PtBi2 as a rare platform where ARPES directly reveals superconductivity of topological surface states, paving the way toward intrinsic realizations of Majorana physics.

[1] S. Borisenko The Role of A in ARPES, Journal of Synchrotron Radiation **33**, 3 693 (2026)

[2] A. Kuibarov *et al.* Evidence of superconducting Fermi arcs, Nature **626**, 294 (2024)

[3] S. Changdar *et al.* Topological nodal i-wave superconductivity in $PtBi_2$, Nature **647**, 613 (2025)

[4] A. Kuibarov *et al.* Measuring superconducting arcs by ARPES, PRB **112**, 144518 (2025)

[5] A. Kuibarov *et al.* Three prerequisites for high-temperature superconductivity in t-$PtBi_2$, arXiv:2509.02178

Stuart Brown, University of California, Los Angeles

Antiferromagnetism, Magnetic Fluctuations and the Superconducting State of Sr2RuO4
Abstract: TBD

Jefferson Carter, *University of Wyoming*

Exploration of bulk crystal 2M-WS_2, a topological superconductor candidate

In recent years great interest has been applied to topological superconductors as a means of building noise-resilient qubits. One such candidate is the monoclinic transition metal dichalcogenide (TMD) 2M-WS_2. This material is ideally suited to qubit applications due to its relatively high Tc (~8.8 K), as well as the ease of converting narrow trenches in each crystal to 2H-WS_2 (a known insulator), which facilitates Josephson junction device design.

Large 2H-WS_2 crystals have been grown stoichiometrically, then intercalated with a Na solution to convert to the monoclinic phase. These intercalated crystals are then deintercalated via ($K_2Cr_2O_7$+H_2SO_4), leaving behind pristine 2M-WS_2 crystals. The phase conversion was verified via XRD, and the removal of Na confirmed by energy-dispersive X-ray spectroscopy.

Magnetization and electrical transport measurements were used to characterize the superconducting transition and the anisotropy of the superconducting state, by observing the variation in upper critical fields (7 T along the [100] crystal orientation and 4 T normal to the [100] crystal orientation). Heat capacity measurements were also performed to further characterize the superconducting transition.

Upon doping Nb the majority carrier becomes holes and by doping with Ta to enhance the spin-orbit coupling and decrease the electron density at the fermi energy; both of which changes the superconducting transition temperature in a non-uniform manner. Re-doping was also performed, with the intent of changing the superconducting anisotropy (as ReS_2 is strongly anisotropic). The transition temperatures of doped 2M-WS_2 powders were finally explored via magnetization measurements to determine changes in Tc.

Colorado State University Analytical Resources Core (RRID: SCR_021758)

National Science Foundation - Expand-QISE OMA MPS-2228841.

Mun Chan, *National High Magnetic Field Laboratory: Pulsed Field Facility*

Observation of the Yamaji effect in a cuprate superconductor

The nature of the pseudogap state of high-temperature superconducting cuprates, known for its partial gapping of the Fermi surface above the superconducting transition temperature, remains a vital open question. We report pulsed magnetic field angle dependent magnetoresistivity measurements in the cuprate $HgBa_2CuO_{4+\delta}$ [1]. We observe the Yamaji effect, which appears as a peak in the c-axis resistivity at a specific angle of the applied magnetic field in the pseudogap state above the superconducting critical temperature. The observation of the Yamaji peak is evidence for small Fermi-surface pockets in the normal state of the pseudogap phase. The small size of the pockets, each estimated to occupy only 1.3% of the Brillouin zone area, is not expected given the absence of long-range broken translational symmetry.

[1] Chan, M.K., Schreiber, K.A., Ayala-Valenzuela, O.E. *et al.* Observation of the Yamaji effect in a cuprate superconductor. Nat. Phys. **21**, 1753–1758 (2025).

Lu Chen, *University of Illinois Urbana-Champaign*

Bulk Superconductivity driven by Disorder-Induced Delocalization in 4Hb-Ta($S_{1-x}Se_x$)$_2$

The unconventional superconductor 4Hb-TaS_2 is a natural heterostructure that can be broadly understood as interleaving Mott-like and metallic layers. We study the properties of this material as a function of quenched disorder in the form of Se/S substitution and find that while disordered samples show bulk superconductivity, clean samples do not. We show that a disorder-driven delocalization of carriers in the Mott-like (1T-) layer forms a new Fermi surface that is absent in the cleanest samples. This suggests that one of the primary drivers for superconductivity is the fragility of the flat band, whose delocalization brings to life a sea of strongly correlated electrons.

arXiv:2606.07509

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AC02-05CH11231. We thank Chris Jozwiak and Aaron Bostwick for stimulating discussions and assistance with beamtime at the ALS.

Wonjune Choi, *Los Alamos National Laboratory*

Measuring Anyonic Exchange Phases Using Two-Dimensional Coherent Spectroscopy

Identifying experimental signatures of anyons, which exhibit fractional exchange statistics, remains a central challenge in the study of two-dimensional topologically ordered systems. Previous theoretical work has shown that the threshold behavior in linear response spectroscopy can reveal the fractional exchange statistics between an anyon and its antiparticle. In this work, we extend this framework to nonlinear, two-dimensional coherent spectroscopy. We demonstrate by analyzing time-ordered four-point correlation functions that the threshold behavior of nonlinear response functions encodes the fractional statistics between general pairs of anyons that can combine to any composite topological charge. This feature in particular provides a powerful probe for unambiguously distinguishing non-Abelian anyons, which can form multiple composite charges with distinct nontrivial braid statistics. Our approach is validated using numerical simulations that are consistent

with the correct fractional exchange statistics for both the Abelian anyons in the toric code and non-Abelian Ising anyons.

W.C. is supported at Los Alamos National Laboratory (LANL) which is operated by Triad National Security, LLC, for the National Nuclear Security Administration of U.S. Department of Energy (Contract No. 89233218CNA000001). W.C. also gratefully acknowledges the support of the U.S. Department of Energy through the LANL/LDRD Program and the Center for Nonlinear Studies for this work.

Chung-Hou Chung, *National Yang Ming Chiao Tung University*

A mechanism for quantum-critical Planckian metal phase in high-temperature cuprate superconductors

The mysterious metallic phase showing universal linear-in-temperature scattering rate: $1/\tau = \alpha P\ k_B T/\hbar$ with a universal constant prefactor $\alpha P \sim 1$ and logarithmic-in-temperature singular specific heat coefficient, so-called “Planckian metal phase”, was observed in various high-Tc cuprate superconductors over a finite range in doping near optimal doping [1]. Revealing the mystery of the Planckian metal state is believed to be the key to understanding the mechanism for high-Tc superconductivity. Here, we propose a generic microscopic mechanism for this state based on quantum-critical local bosonic charge Kondo fluctuations coupled to both spinon and a heavy conduction-electron Fermi surfaces within the heavy-fermion formulated slave-boson t-J model [2]. A closely related idea proposed by C.H. Chung and collaborators based on critical Kondo fluctuations near Kondo breakdown quantum critical point has been used to successfully account for quantum critical strange metal states observed in various heavy-fermion compounds [3]. Our approach is motivated by the striking similarity in strange metal phenomenology between cuprates and heavy-fermion Kondo lattice systems. By a controlled perturbative renormalization group analysis of our effective heavy-fermion model, we examine the competition between the pseudogap phase, characterized by Anderson's Resonating-Valence-Bond spin-liquid made of fermionic spin-singlet spinons, and the Fermi-liquid state, modeled by coherent electron hopping (effective charge Kondo hybridization). We find an extended quantum-critical metallic phase with a universal Planckian $\hbar\omega/k_BT$ scaling in scattering rate near a localized-delocalized (pseudogap-to-Fermi liquid) charge-Kondo breakdown transition. The d-wave superconductivity emerges near the transition. Unprecedented qualitative and quantitative agreements are reached between our theoretical predictions and various experiments in cuprates [4,5,6,7,8]. Our mechanism offers a microscopic understanding of how d-wave superconductivity emerges from the quantum-critical Planckian strange metal in high-Tc cuprates, an outstanding open problem since 1990s.

[1] A. Legros et al., Nat. Phys. **15**, 142 (2019).

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Nicholas Curro, *University of California, Davis*

Measurements of Nematic Susceptibility in Iron-based Superconductors via NMR with Dynamic Strain

We report measurements of the nematic susceptibility in $BaFe_2As_2$ and $CaKFe_4As_4$ using nuclear magnetic resonance in the presence of pulsed strain fields that are interleaved in time with the radio frequency excitation pulses [1]. In this approach, the nuclear magnetization acquires a phase shift that is proportional to the strain and pulse time. The sensitivity is limited by the homogeneous decoherence time, T2, rather than the inhomogeneous linewidth, and we demonstrate three orders of magnitude improvement in sensitivity [2]. This approach enables studies of the strain response that previously were inaccessible due to inhomogeneous broadening. Our recent data in the superconductor $CaKFe_4As_4$ reveals little to no change in the nematic susceptibility through Tc, suggesting that the superconducting order is not driven by nematic fluctuations.

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Chunhui Du, *Georgia Institute of Technology*

Quantum Sensing of Superconducting Materials

Recently, spin defect-based quantum sensing has made transformative advances in cutting-edge scientific research and technological innovation. The high field sensitivity, nanoscale spatial resolution together with creative measurement modalities of quantum spin defects open a range of opportunities at the forefront of materials science, condensed matter physics, and quantum technology research [1]. Many of the advantages behind this approach result from the quantum mechanical nature of the sensors offering functionalities not available to their classical counterparts. In this talk, I will present our recent work on using scanning-probe nitrogen-vacancy (NV) quantum microscopy to investigate emergent superconducting materials and devices with nanoscale spatial resolution. Specifically, we utilized NV centers to investigate the exotic topological electromagnetic properties of unconventional superconductor candidate(s) and magnetic noise environment of a superconducting resonator [2]. Lastly, I will report our ongoing efforts in developing next-generation van der Waals quantum sensors—pushing operation of color centers beyond NVs down to millikelvin temperatures [3-6].

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Benedikt Fauseweh, *TU Dortmund University*

Collective excitations and long-range interactions in superconductors

In this talk we investigate non-equilibrium dynamics and the interplay of long-range interactions in superconducting systems. Building on earlier work classifying Higgs modes in unconventional superconductors and probing out-of-equilibrium condensates via time-resolved ARPES [1,2,3], we focus on three recent advances. First, we study the photoinduced η-pairing state in the one-dimensional Hubbard chain [4]. We show that a pump-probe protocol transiently breaks the η symmetry, giving rise to dynamic Higgs oscillations that manifest as a sharp negative optical conductivity peak above the Mott gap, indicating a spectroscopic signature that distinguishes light-induced superconductivity from doublon excitations. Second, we extend the Kitaev chain to include self-consistent power-law long-range interactions [5], revealing that topological edge modes hybridize non-locally and acquire a finite mass with algebraic system-size scaling, despite exponential wavefunction localization. Finally, bringing long-range interactions and non-equilibrium dynamics together [6], we demonstrate that the strength of the long-range interaction acts as a tuning parameter for the Higgs mode frequency, shifting it below or above the superconducting gap and thereby controlling whether the Higgs mode is stable or unstable.

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Atsushi Fujimori, *National Tsing Hua University*

Nodal metal versus hole pockets and interlayer coupling in multilayer cuprates

In multilayer cuprates, the maximum Tc,max is the highest at n = 3 (triple-layer) in all cuprate families. For the inner CuO_2 planes of n > 5, antiferromagnetic (AFM) order has been confirmed by NMR, and ARPES studies have shown small hole Fermi pockets in the inner CuO_2 planes as a result of AFM band folding.

Here, we report ARPES data of the triple-layer cuprates Bi2223 over a wide doping range covering from underdoped to overdoped regions. In the inner CuO_2 plane of underdoped samples, the doping level of became extremely low but the d-wave superconducting gap is enhanced to an unprecedentedly large value of nodal gap Δ_0 ~ 100 meV, and the gap persisted up to ~2Tc without the appearance of a Fermi arc, indicating a robust nodal metal. We attribute the nodal-metallic behavior to the unique local environment of the inner CuO_2 plane in the triple-layer cuprates, sandwiched by optimally-doped two outer CuO_2 planes and hence subject to strong proximity effect from both sides. Such a situation is realized only in triple-layer cuprates, and explains why the Tc reaches the maximum at n = 3 in every cuprate family.

While it has been established that underdoped to optimally doped Bi2223 show distinct Fermi surfaces for the inner and outer CuO_2 planes [2], a resent ARPES study on overdoped Bi2223 has shown further splitting of the outer-plane Fermi surface, resulting in three Fermi surfaces [3]. With additional ARPES data, we find that the transition from the two to three Fermi surfaces is accompanied by enhanced interlayer single-particle hopping and interlayer pairing as the system crosses the quantum critical point at $p \sim 0.19$.

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Xueshi Gao, *The Ohio State University*

Tuning electronic interaction in superconducting twisted multilayer graphene family

The superconductivity (SC) in twisted trilayer graphene (TTG) shows intriguing features that are not shown in twisted bilayer graphene (TBG), indicating a possibly different pairing mechanism from TBG. One can shed light on the pairing mechanism by investigating the dependence of SC on electronic interactions in TTG. However, it is challenging to control displacement field D with fixed interaction level. In this work, we study the effect of ε-tuning on twisted multilayer graphene. Latest experimental results will be discussed and compared to various theoretical models.

David Haink, *DLR e.V.*

Real space properties of a topological long-range p_x+ip_y-wave superconductor

Topological superconductors offer a path to fault-tolerant quantum computing by braiding of zero-energy anyonic quasiparticles known as Majorana zero-modes. A possible route to realize a topological p_x+ip_y-wave superconductor are microwave-dressed dipolar fermionic molecules confined to a surface, e.g. NaK [1,2]. In our contribution we simulate the superconductor self-consistently in real space using the BCS mean-field approximation including long-range dipolar interactions. We demonstrate, although the Majorana modes are exponentially localized, the edge modes hybridize through the long-range interaction [3], leading to spurious phases when braiding two Majoranas localized on vortices. This dephasing is directly dictated by the power-law exponent of the long-range interaction. Additionally, upon increasing temperature, we find that, in contrast to the bulk of the superconductor, the critical temperature is enhanced at the boundaries. Furthermore, we compute the superfluid density contributions from the bulk and the boundary to understand this effect.

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Tetsuo Hanaguri, *RIKEN*

Twist Engineering of the Superconducting Gap in $NbSe_2$ Monolayers on Graphene

When two metallic layers are stacked, the overlap of their Fermi surfaces can be tuned by the twist angle between the layers. Here, we perform scanning tunneling microscopy and spectroscopy (STM/STS) on superconducting $NbSe_2$ monolayer islands on graphene to investigate the impact of Fermi surface overlap on superconductivity. In situ and continuous control of the twist angle is achieved by manipulating the $NbSe_2$ islands using the STM tip, followed by ultra-low-temperature STS measurements that allow us to probe changes in the superconducting gap. We find that the gap magnitude varies by nearly a factor of two as a function of the twist angle: the gap is minimized and maximized when the graphene Fermi surface overlaps with the $NbSe_2$ Fermi surfaces around the Γ and K points, respectively. These results suggest orbital-dependent interlayer coupling and provide a route toward the systematic exploration of twist-controlled quantum states.

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Russell Hemley, *University of Illinois Chicago*

Progress in High Tc Superconductivity Under Pressure

Efforts to realize superconductivity at ever higher temperatures, a longstanding goal in physics, have been reported in hydrogen-rich materials under pressure. Theoretical calculations using density functional theory-based structure-search methods combined with conventional electron-phonon theory predicted a new class of dense, hydrogen-rich materials, or superhydrides (MH_n, $n \geq 6$), with superconducting critical temperatures (Tc's) near room temperature at pressures ranging from 100 to 300 gigapascals (GPa). These developments highlight the novel physics of superhydrides at high densities and the success of 'materials by design' in discovering new compounds. Experimental realizations of several predicted high-Tc hydrides have further strengthened the link between theory and experiment, pointing toward new classes of superconductors with Tc's above room temperature. The current focus is shifting toward exploring broader chemical complexity, moving from binary to ternary and more complex systems, including reports of room-temperature superconductivity. Molecular-type hydrides are also emerging as viable candidates for high-Tc superconductivity at lower pressures, challenging the traditional dichotomy between atomic and molecular hydrogen. Outstanding questions include the extent to which Tc's well above room temperature are possible, how such states may be stabilized through carrier doping or chemical tuning, whether this superconductivity differs fundamentally from conventional types, and possible routes for discovering high-Tc materials near ambient pressure. There are prospects for higher Tc superconductivity in other systems such as cuprates over a range of pressures. Recent work on $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi-2223) using multiple probes of superconductivity provide evidence for Tc of 190 K at 60 GPa.

Numerous collaborators at UIC and other institutions contributed to this work, which was supported by This work was supported by the DOE-NNSA (DE-NA0004153, CDAC), NSF (DMR-2104881), DOE-SC (DE-SC0020340 and DE-AC02-06CH11357). This work is a contribution from the George W. Crabtree Institute for Discovery.

Eduardo H. da Silva Neto, *Yale University*

Pairing mediated by nematic fluctuations in an iron-based superconductor

Electronic nematic phases, in which electrons in a solid spontaneously break rotational symmetry, exist in several families of unconventional superconductors. Although long-range nematic order can either compete with or enhance superconductivity, the influence of nematic fluctuations on pairing remains unresolved. Although long-range nematic order can either compete with or enhance superconductivity, the influence of nematic fluctuations on superconducting pairing mechanisms remains unresolved. However, as recently highlighted [Nature Physics, 18, 1412 (2022)], how nematicity influences superconductivity and whether nematic fluctuations can create superconductivity on their own are crucial questions in the field. One major challenge is that nematicity is often intertwined with magnetism. The FeSe1−xSx family of superconductors provides an opportunity to explore this concept, as it features an isolated nematic phase that can be suppressed by sulfur substitution at a quantum critical point where the nematic fluctuations are the largest. We performed scanning tunnelling spectroscopy to visualize Boguliubov quasiparticle interference patterns, from which we determined the momentum structure of the superconducting gap near the Brillouin zone Γ point of $FeSe_{0.81}S_{0.19}$ [Nag et al. Nature Physics 21, 89–96 (2025)]. The results reveal an anisotropic, near nodal gap with minima that are 45° rotated with respect to the Fe-Fe direction, in stark contrast to the usual isotropic gaps due to spin-mediated pairing in other tetragonal Fe-based superconductors. Instead, we find that the gap structure agrees with theoretical predictions for superconductivity mediated by nematic fluctuations.

Nag *et al.* Nature Physics **21**, 89–96 (2025)

Suguru Hosoi, *Los Alamos National Laboratory*

Pseudo Point Nodes in Spin Triplet superconductor UTe_2

UTe_2 provides an ideal platform for studying spin-triplet superconductivity, owing to the absence of competing magnetic order under ambient conditions and its relatively simple Fermi-surface topology. A key issue in understanding its pairing mechanism is the determination of the superconducting gap structure, which is closely related to the electron-pairing interaction. Although various studies have investigated the gap structure of UTe_2, the presence or absence of point nodes along the b axis remains one of the central controversies. To address this issue, we performed directional, bulk-sensitive thermal conductivity measurements on high-quality single crystals grown by the molten-salt flux method, with magnetic fields applied along all principal crystallographic directions. To maximize the contribution from the putative nodal quasiparticles, the thermal current was applied along the b axis. The field dependence of the* residual thermal conductivity along the b axis exhibits a clear kink at a threshold field, indicating that Doppler-shifted quasiparticle excitations become active in thermal transport in the vortex state only above this field. These results strongly suggest that UTe_2 hosts a highly anisotropic but nodeless superconducting state with finite gap minima along the b axis. In the presentation, we will discuss the detailed field-orientation dependence of the thermal conductivity and its implications for the superconducting gap structure.

Work at LANL was supported by the U.S. Department of Energy, Office of Basic Energy Sciences, Division of Materials Science and Engineering project “Quantum Fluctuations in Narrow-band Systems”. S.H. acknowledges the Directors's Postdoctoral Fellowship through the LDRD program at LANL.

Masatoshi Imada, *Sophia University / University of Tokyo*

Cuprate Superconductors – View from AI Aided ab initio Studies and Integrated Spectroscopy Analysis

Recently various spectroscopic measurements have consistently supported the emergence of electron fractionalization in cuprate superconductors [1-5], where an electron is splintered into entangled multiple fermions. This fractionalization is entirely different from previous proposals such as in Su-Schrieffer-Heeger model, fractional quantum Hall effect, spin-charge separation and slave boson (fermion) scenario. Instead, an electron is splintered into weakly-interacting two or more fermions originated from a universal mechanism near local instability toward first-order transition. This is also related with representability of interacting single-component fermions by noninteracting multiple-component fermions. This fractionalization with emergence of dark (hidden) fermions results in remarkable cancellation of normal and anomalous self-energy of single-particle Green’s function, thereby the main signature of high-Tc superconductivity in the anomalous self-energy becomes apparently hidden in experimental data as in ARPES and STM [1, 2].

Meanwhile, multi-scale ab initio scheme for strongly correlated electrons (MACE) [6-8] has enabled to reveal detailed materials dependent superconducting properties by solving ab initio low-energy effective Hamiltonians without adjustable parameters using accurate quantum many-body solvers in combination of refined variational Monte Carlo aided by neural network [9]. The results [10,11] have quantitatively reproduced the diverse materials dependence of the experimental data of d-wave superconductivity for carrier doped $CaCuO_2$, $Bi_2Sr_2CuO_6$, $Bi_2Sr_2CaCu_2O_8$, $HgBa_2CuO_4$ together with pressure dependence of HgBa2Ca2Cu3O8. It allows pursuit of realistic superconducting mechanism from the ab initio data: Originally strong local Coulomb repulsion counterintuitively and emergently turns into instantaneous and local attraction in its carrier concentration dependence in the d-wave superconducting phase. This attraction has nice correspondence with the calculated superconducting order parameter [10,11] indicating the pairing directly caused by this emergent attraction without glues. This “attraction by repulsion” is understood to arise from reduced repulsion from the “false vacuum”. The emergent attraction and electron fractionalization supported by spectroscopic studies are understood from the same mechanism.

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Takashi Imai, *McMaster University*

Quantum Critical Spin Excitations in LSCO High Tc Cuprates

Enhanced spin fluctuations near the pseudogap quantum critical point (QCP) have long been speculated to play a crucial role in the Cooper pairing mechanism of high Tc cuprate superconductors. Nuclear magnetic resonance (NMR) is an ideal probe to investigate enhanced low energy spin excitations in the vicinity of the QCP, but the growing distributions in the NMR spin-lattice relaxation rate 1/T1 in the overdoped regime hampered the past effort to identify the QCP and elucidate enhanced spin fluctuations in its vicinity. Recent introduction of the inverse Laplace transform (ILT) T1 analysis technique enabled us to overcome such difficulties by allowing us to deduce the average value of the distributed 1/T1 along with the density distribution function P(1/T1) (i.e. the histogram of the distributed 1/T1) [1-2]. In this talk, we will describe how we apply the novel ILT techniques to identify the pseudogap QCP of $La_{2-x}Sr_xCuO_4$ cuprates, and demonstrate the gradual emergence of the mass-enhanced Fermi liquid beyond the QCP.

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Andreas Kreisel, *Uppsala Universitet*

D-vector spectroscopy in triplet superconductors

The heavy-fermion compound UTe_2 is a candidate for hosting intrinsic spin-triplet superconductivity. At present, however, the type of triplet Cooper pairing realized in UTe_2 remains unknown, which calls for further experimental and theoretical investigations. Using a microscopic minimal model for the superconducting phases [1], we examine which imprints of the superconducting order parameter occur on the surface spectral function. Crystalline symmetries determine the properties of the topological surface states allowing to discriminate superconducting order parameters transforming differently under symmetries on the surface. Another symmetry aspect is the time-reversal symmetry which protects the low energy surface state. Breaking it, makes the surface spectral function more similar to the bulk which can be detected within surface spectroscopy [3].

From the perspective of the bulk superconductivity, it turns out that the relative direction of the d-vector that parameterizes the triplet order parameter can be detected in data from quasiparticle interference [2]. We show that beyond the enhanced density of states close to the nodes, one is able to distinguish the allowed superconducting ground states B2u and B3u as proposed for UTe_2.

Technical complications of these investigations are the body-centered orthorhombic structure allowing a number of pairing contributions leading to accidental nodes on the Fermi surface, the nature of the electronic states exhibiting strong spin orbit coupling and the fact that atomically flat surfaces suitable for scanning tunneling microscopy can only be achieved on a (0-11) cleaving plane.

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Elizabeth Krenkel, *Los Alamos National Laboratory*

Oxygen Intercalation and Phase Transition in Sr-substituted 214 Ruddledsen-Popper Nickelates

Thin film Ruddlesen-Popper nickelate phases have recently attracted significant interest as both high-pressure and epitaxially strained superconductors, and to a lesser degree as potential ionic conductors. Recently in pursuit of superconductivity in these compounds, a new oxygen-intercalated phase was reported for the first time with a modified perovskite oxide structure [1]. This induces a significant (18%) expansion of the c-axis for the formation of a the new phase, and also creates significant oxygen vacancies in the interstitial layer [1]. Initially reported in the pure La_2NiO_4 phase, in this work, we report on Sr-substituted 214 system. Basic physical properties are reported including transport and XRD data of the system going through this phase change. To untangle the role of strain, composition, and ozone penetration,, films grown on different substrates ranging from a lattice mismatch of +0.63% ($NdGaO_3$ [110]) to -3.19% (YAlO3 [101]). From this data, we discuss the impact of strain and thickness on both this phase transition and final material properties of these nickelate films.

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Inho Lee, *Los Alamos National Laboratory*

Tunable Anisotropy of High-Harmonic Generation in $NbOI_2$

High harmonic generation (HHG) serves as a source of soft X-rays and a powerful probe of ultrafast electron dynamics. In ferroelectric materials, HHG spectra are influenced by spontaneous electric polarization, and even-order harmonics appears due to the broken inversion symmetry. In spite of recent investigations, the characteristics of even-order HHG in ferroelectric materials are less well understood. In this presentation, we focus on HHG spectra of ferroelectric material compound $NbOI_2$, which has been actively investigated by virtue of stable ferroelectricity in thin film and high temperature. We have calculated HHG spectra using real-time time-dependent density functional theory (RT-TDDFT) under external fields of varying frequencies and polarizations. Our simulations reveal the tunability of angle-dependent even-order HHG. The second and fourth harmonics showed distinct wavelength dependences of their anisotropy. We ascribe distinct anisotropy of the even harmonics to differences in interband couplings by transition dipole matrix analysis. These results establish a microscopic link between ferroelectric crystal anisotropy and nonlinear optical emission. They also provide a pathway optical manipulation of angle-dependency of even-order harmonics which is applicable for optical switches.

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Jiarui Li, *Stanford University*

Superconductivity and spin density wave order in bilayer nickelate

The discovery of high-Tc superconductivity in Ruddlesden-Popper nickelates has sparked substantial effort towards understanding unconventional electronic states beyond a traditional cuprate-like d9 configurational ground state. An understanding of the interplay between competing ground states and multi-orbital physics is key to establishing a

microscopic mechanism for superconductivity. In bilayer nickelates, spin density wave (SDW) order is a prominent feature in the non-superconducting regime, yet its relation to superconducting pairing remains an open question. Here, we use resonant x-ray scattering to examine the existence of SDW order in superconducting bilayer nickelate thin films $La_2PrNi_2O_7$ (LPNO). Comparing superconducting and oxygen-deficient LPNO thin films, we find that superconductivity occurs in SDW-free, oxygen-stoichiometric regions, whereas oxygen deficiency promotes SDW order, indicating phase segregation of SDW and superconductivity. Furthermore, Ni-L_3 and O-K edge spectroscopy reveals distinct c-axis electronic structures between the two phases. Our results suggest that the oxygen stoichiometry serves as an effective control parameter for interlayer coupling through modulation of apical ligand orbital filling, thus controlling the electronic ground states of bilayer nickelates. In concert with theory, a ligand hole residing on the inter-bilayer apical oxygen promotes an interlayer five-spin polaron state, which potentially serves as the ground state for superconducting bilayer nickelates.

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Andrew Li, *University of Michigan, Ann Arbor*

Agentic Workflow for Many-Body Bandgap Optimization

Due to the high-dimensional parameter space, even for highly restricted classes of Hamiltonians, designing moiré materials with large many-body gaps has remained computationally challenging and has been guided primarily by symmetry-based intuition, such as Landau-level mimicry [1]. Recent breakthroughs from the Sun group [2,3], however, have shown that additional effects, such as band vortexability, can significantly enhance the band gap, challenging widely accepted parameter-design strategies. To address the difficulty of applying human intuition in high-dimensional design spaces, we develop an agentic workflow that autonomously explores design options while maintaining interpretability, and we report on its current progress.

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Donghui Lu, *SLAC National Accelerator Laboratory*

Electronic structure of compressively strained bilayer nickelate thin film

The discovery of superconductivity in bulk bilayer nickelates under high pressure, and its subsequent stabilization in compressively strained thin films at ambient pressure, has established a new platform for exploring high-Tc superconductivity beyond the cuprates. Central to this development is the prominent role of the $3d_{z2}$ orbital in shaping the low-energy electronic structure, imposing constraints on microscopic theories and fueling debate over the superconducting mechanism. Here we report a systematic in situ angle-resolved photoemission spectroscopy study of compressively strained bilayer nickelate thin films spanning Ca doping, oxygen stoichiometry and film thickness. Despite variations in oxygen-vacancy disorder and surface termination, the electronic structure remains robust and exhibits a systematic strain-driven evolution consistent with an intermediate-correlation regime. In particular, we demonstrate a Ca-doping-induced electronic structure evolution that is consistent with Fermi-level crossing of the γ band and is decoupled from the presence of superconductivity, suggesting that, while important for γ band to be near the Fermi level, the debated γ crossing and the resulting Fermi-pocket may not be a prerequisite for superconductivity. Together, our results establish key spectroscopic constraints on the minimal fermiology and correlation strength relevant to superconductivity in bilayer nickelates, providing an experimental foundation for microscopic theories of their pairing mechanism.

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Ayanesh Maiti, *Max Planck Institute for Chemical Physics of Solids*

Enhanced specific heat anomaly in clean overdoped Tl2201

The loss of superconductivity in overdoped cuprates remains poorly understood, in part due to the difficulty of disentangling intrinsic thermodynamic behavior from disorder-induced suppression effects [1–2]. High-quality single crystals of Tl2201 provide a key model system in which transport, quantum oscillations, and ARPES measurements indicate a simple Fermi-liquid-like normal state [3–5]. However, specific heat studies of Tl2201 have largely been limited to powder samples [6], where disorder-induced broadening can strongly suppress the superconducting anomaly and obscure intrinsic thermodynamics. Here we report high-resolution AC membrane nanocalorimetry measurements of microgram-scale Tl2201 single crystals spanning T_c = 14–30 K. The total specific heat agrees quantitatively with established literature values, enabling a direct comparison to prior powder-based measurements. We find that the superconducting specific heat anomaly is more than twice as sharp in single crystals as previously reported [6,7], with a transition width $\Delta T_c \sim 1$ K. The superconducting transition is consistently mean-field-like across the studied doping range, and the specific heat jump $\Delta\gamma(T_c)$ is approximately doping-independent, despite a factor-of-two decrease in T_c with overdoping. Over the same doping range, the Fermi surface remains large, with <4% change in Luttinger volume. Together with the nearly constant $\Delta\gamma(T_c)$, this places strong constraints on microscopic models of overdoped cuprate superconductivity, indicating that T_c suppression occurs without substantial reconstruction of the underlying electronic structure.

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Ludi Miao, *New Mexico State University*

Field-Robust Two-Dimensional Superconductivity in Ultrathin Sr_2RuO_4 Heterostructures

Sr_2RuO_4 remains one of the most intensively studied unconventional superconductors, yet realizing superconductivity in thin films has been a longstanding challenge because of its extreme sensitivity to disorder and the emergence of nonsuperconducting dead layers. We demonstrate an interface-engineering approach that preserves superconductivity in ultrathin Sr_2RuO_4 by incorporating lightly Ba-substituted Sr_2RuO_4 buffer layers into Ba:Sr_2RuO_4/Sr_2RuO_4/Ba:Sr_2RuO_4 heterostructures. Angle-resolved photoemission measurements confirm that the low Ba concentration does not significantly alter the electronic structure, while transport measurements reveal superconductivity in Sr_2RuO_4 layers as thin as 3 nm, comparable to the out-of-plane Cooper-pair coherence length. Thickness-dependent critical current measurements indicate that superconductivity originates from the Sr_2RuO_4 layer rather than Ba interdiffusion. Magnetotransport measurements further reveal a distinct two-dimensional resistive regime with an unusually robust in-plane critical field at low current densities, differing from conventional two-dimensional superconductors. These results establish a practical platform for investigating two-dimensional superconductivity in Sr_2RuO_4 at the Cooper-pair length scale and provide new opportunities for exploring the pairing symmetry and interfacial physics of this unconventional superconductor.

Ghulam Mohmad, *Indian Institute of Science Education and Research (IISER) Mohali*

Role of Local Strain Field in Tip-induced Superconductivity

A metallic point contact formed on a non-superconducting or weakly superconducting material can nucleate or enhance superconductivity confined under the contact. We show that the spatially inhomogeneous, predominantly uniaxial stress field under a point contact is fundamental to such tip-induced and tip-enhanced superconductivity (TISC/TESC). The coupling of this stress field to the electronic structure can be estimated through an experimentally measurable uniaxial coupling scale C^{exp}. Combining Hertzian contact mechanics with a Ginzburg-Landau variational analysis, we derive a criterion for TISC/TESC nucleation and determine Cexp for different materials. As a direct test, we observe TISC in elemental antimony (Tc ≈ 2.8 K) and elemental yttrium (Tc ≈ 1.5–12 K) using point-contact spectroscopy with Pt-Ir and Ag tips. Superconducting signatures appear as Andreev-reflection spectra in ballistic contacts and as critical-current features in the thermal regime. In Y, Tc varies substantially from junction to junction, with the highest values approaching those achieved in bulk Y only above ≈50 GPa. Since pressures accessible under the point contact fall well below those required to induce bulk superconductivity in either material, the observed phases cannot be explained by simple hydrostatic-pressure effects. Instead, the results highlight the role of the highly localized, predominantly uniaxial strain field generated beneath the tip. For Sb, similarities with isostructural grey As suggest that surface or near-surface electronic states help stabilize the superconducting phase. For Y, the large junction-to-junction variation in Tc and the magnitude of the highest observed values indicate a uniaxial coupling scale C^{exp} ≈ 200–250K far exceeding what the hydrostatic pressure alone would imply, identifying uniaxial strain as the dominant pairing-enhancement channel.

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Mohd Monish, *Indian institute of science education and research (IISER) Mohali*

High Tc conventional superconductivity in cerium point contacts

one of the key objectives of modern condensed matter research is the discovery of superconductors with high critical temperatures (Tc) among chemically simple and stable materials. Elemental metals such as calcium, titanium and scandium have been reported to exhibit significantly enhanced Tc under extreme hydrostatic pressures [1,2]. However, the requirement for specialized high-pressure cells restricts their spectroscopic characterization and practical applications.

In this work, we demonstrate a simple and cost-effective technique to induce superconductivity in elemental cerium with a critical temperature exceeding 20 K, achieved by applying high uniaxial pressure through a sharp metallic needle pressed onto the sample. This finding is novel, as pure cerium exhibits superconductivity only under high hydrostatic pressures, with a maximum Tc of about 1.8 K even at pressures up to 54 GPa [3,4]. Furthermore, by driving the mesoscopic point contact in the ballistic regime of transport, we have spectroscopically characterized this new superconducting phase in detail and show that superconductivity respects BCS theory.

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Adriana Moreo, *University of Tennessee / Oak Ridge National Laboratory*

Theoretical and Computational Overview of High Tc superconductivity in nickelates

The discovery of superconductivity in the infinite layer nickelates started a novel field within unconventional superconductivity, allowing a comparison with the cuprates [1]. The observation of pressure-induced superconductivity at 80K in the bilayer $La_3Ni_2O_7$ (LNO), and in the trilayer $La_4Ni_3O_{10}$, different from the infinite layer nickelates, has unveiled a new window into high-Tc superconductivity where the Ni orbital degrees of freedom play a key role.

We investigated theoretically the whole family of bilayer 327-type nickelates $R_3Ni_2O_7$ (R = rare-earth elements from La to Lu) [2,3,5,6,8], as well as the non-superconducting bilayer $La_3Ni_2O_6$ [4], and the trilayer $La_4Ni_3O_{10}$ [7], all under pressure. Initial studies using density functional theory (DFT) allowed to identify a structural phase transition that occurs under pressure [2] and the relevance of two active orbitals, d_{3z2-r2} and d_{x2-y2}, near the Fermi energy, instead of just one active orbital as in the cuprates. This allowed us to construct a two-orbital model Hamiltonian with Hubbard and Hund interactions, and crystal field, whose parameters and geometry were adapted to each of the investigated materials [2-8] and studied using primarily the random phase approximation to incorporate electronic correlations. Some results were also obtained with the density matrix renormalization group[8].

We found that the s±-wave pairing tendency dominates the multilayer structures, due to the nesting between the M = (π,π) and the X = (π , 0) and Y = (0, π) points in the Brillouin zone [4]. The nesting is associated to magnetic tendencies and the lack of nesting and pockets around M = (π,π) in $La_3Ni_2O_6$ may explain the absence of superconductivity in this material [3]. The pairing tendencies in thin films of $La_3Ni_2O_7$ at ambient pressure in which a d-wave pairing state prevails due to the suppressed ratio of interlayer d_{3z2-r2} hopping to intralayer d_{x2-y2} hopping will be discussed [9].

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Philip Murgatroyd, *Los Alamos National Laboratory*

Termination-dependent charge transfer enhances the Kondo coupling strength in $CeCoIn_5$

The reduction of beam spot sizes at modern synchrotron facilities has transformed angle-resolved photoemission spectroscopy (ARPES) into a powerful spectro-microscopy probe. In the layered heavy-fermion compound $CeCoIn_5$, this enables us to resolve and compare distinct surface terminations hosting distinctive electronic structures. Using spatially resolved ARPES, we identify two terminations exhibiting markedly different degrees of c-f hybridization. We show that these differences originate from variations in surface charge transfer, with the more electron-rich termination exhibiting stronger hybridization. Controlled in situ alkali dosing further enhances the surface electron density and concomitantly increases the Kondo coupling strength, providing direct spectroscopic evidence for tunable hybridization in a heavy fermion compound. These results establish a new route for visualizing and manipulating the Kondo interaction in quasi-two-dimensional heavy-fermion systems.

Muntaser Naamneh, *Ben Gurion University*

Universal Four-Fold Symmetry in Infinite-Layer Nickelates

The discovery of superconductivity in nickelates has motivated intensive efforts to identify the fundamental interactions that mirror or distinguish them from high Tc cuprate superconductors. Nickelate superconductors, which are hole-doped within the layered structure of $RNiO_2$, share structural similarities with high Tc cuprate superconductors. However, despite similarities in formal valence and crystal symmetry, the fundamental nature of the superconducting state and the parent compound phase in nickelates remains elusive. Strong electronic correlations in infinite-layer nickelates suggest a potentially complex phase diagram, akin to that observed in cuprates, yet a key question about the magnetic ground state remains unanswered. Through magnetoresistance measurements, we observe a universal fourfold rotational symmetry that persists across the entire doping range, from the weakly insulating parent compound to the superconducting state. Notably, this four-fold symmetry displays a pi/4 phase shift with doping or applied magnetic field. This universal symmetry and its characteristic phase shift strikingly parallel the behavior of the electron-doped cuprates, where such signatures are tied to underlying magnetic order. Our modeling suggests that this persistent anisotropy is consistent with the influence of an underlying antiferromagnetic order, providing a unified framework for the electronic ground state throughout the nickelate phase diagram.

Stevan Nadg-Perge, *Caltech*

Resolving spectral gaps and many-body resonances in superconducting twisted trilayer graphene

Magic-angle twisted trilayer graphene (MATTG) exhibits a plethora of strongly correlated electronic phases that spontaneously break its underlying symmetries. Despite great experimental efforts, the microscopic nature of these phases and their relationship to emerging superconductivity in this system are still elusive. In this talk, I will present our latest results on scanning tunneling microscopy experiments that focus on tracking the formation of correlated phases preceding superconductivity in MATTG. Surprisingly, in a certain range of filling factors within the superconducting dome, we discover the existence of two well-resolved gaps pinned at the Fermi level. While the outer gap, previously associated with the pseudogap phase, persists at high temperatures and magnetic fields, the newly revealed inner gap is more fragile in line with superconductivity MATTG transport experiments. I will discuss several additional measurements that further corroborate the superconducting nature of the inner gap and strongly suggest that the outer gap originates from the splitting of the many-body Kondo-like resonance due to the breaking of the valley symmetry. Our results suggest an intricate hierarchy of correlated phases in MATTG.

Hari Padma, *Case Western Reserve University*

Electronic metastability in a driven cuprate ladder

Driving quantum materials with intense optical pulses offers a powerful means to control their behavior, leading to remarkable emergent phenomena such as photoinduced magnetic, topological, and superconducting phases. However, such phenomena are usually transient, limited to the sub-picosecond duration of the optical pulse or decaying shortly thereafter. Advancing the design and control of light-driven quantum materials therefore requires targeted strategies to achieve long-lived, metastable phases. In this talk, I will describe how symmetry protection leads to electronic metastability [1] in a prototypical cuprate ladder compound, $Sr_{14}Cu_{24}O_{41}$. This finding is enabled by femtosecond resonant x-ray spectroscopy, which provides unprecedented access to correlated electronic phenomena far from equilibrium. Our measurements show that the metastability is driven by a transfer of holes from chain-like charge reservoirs into the ladders. This ultrafast charge redistribution arises from the optical activation of a hopping pathway that is otherwise forbidden by symmetry. Relaxation back to equilibrium is hence suppressed once the optical pulse ceases. Remarkably, we find that this trapped nonequilibrium electronic distribution hosts a propagating, collective charge mode that is absent at equilibrium, representing a possible precursor to an electronic condensate [2]. Our results demonstrate how dressing quantum materials with electromagnetic fields can provide a rational design strategy for emergent nonequilibrium phases of matter.

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Pyeongjae Park, *Oak Ridge National Laboratory*

Spin dynamics and superconductivity in $CeCoIn_5$ from high-resolution inelastic neutron scattering

$CeCoIn_5$ is a prototypical d-wave heavy-fermion superconductor whose normal state lies close to an unconventional quantum critical point. The interplay between its spin dynamics and superconductivity is the subject of ongoing debate. In this talk, I will present state-of-the-art inelastic neutron scattering (INS) measurements of the spin excitations in $CeCoIn_5$ across the superconducting transition. Below Tc, we resolve a quasi-2D dispersion of the gapped spin-resonance mode—refining earlier INS reports—and uncover a broad scattering continuum coexisting with it. Importantly, this continuum persists in structured form above Tc, revealing strong antiferromagnetic correlations in the normal state. The continuous evolution of the gapped spin resonance into this gapless continuum across Tc calls for a theoretical framework that can capture both coherent and incoherent magnetic responses across energy-momentum space, by treating antiferromagnetic correlations and superconductivity on equal footing. I will close by discussing an interpretation based on spin fractionalization in the normal state, which provides a unified framework for the d-wave pairing and spin resonance in strongly correlated metals close to quantum critical points.

P. Park *et al.*, arXiv:2604.02481

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Tuson Park, *Sungkyunkwan University*

Spectroscopic Study of Pseudogap in Ce-based Heavy Fermion Superconductors

The discovery of the pseudogap state in strongly correlated electron systems has attracted intense interest over the past several decades because of its potential connection to emergent quantum phenomena, including high-Tc superconductivity and non-Fermi-liquid behavior. Despite extensive efforts to elucidate the nature of the pseudogap, its microscopic origin remains highly controversial, particularly regarding whether it reflects preformed Cooper pairs lacking long-range phase coherence. Heavy-fermion superconductors exhibiting pseudogap behavior are especially intriguing because they share many key characteristics with high-Tc cuprates, while being comparatively less influenced by thermal fluctuations and chemical disorder that often complicate investigations of the pseudogap phase. Here, we present evidence for a novel type of pseudogap state realized in the heavy-fermion superconductor family CeMIn5 (M= Co, Rh, Ir). Our results suggest that this enigmatic quantum state is unlikely to originate from superconducting pairing correlations; instead, it appears to be governed by quantum entanglement between localized Ce 4f moments and surrounding itinerant electrons. These findings provide new insight into the long-standing problem of unconventional superconductivity and the fundamental issue of f-electron delocalization in correlated quantum materials.

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Jedediah Pixley, Rutgers University

Twisted Nodal Superconductors

Abstract: TBD

Km Rubi, *Los Alamos National Laboratory*

High field re-entrant superconductivity in infinite-layer nickelates

Magnetic fields typically suppress superconductivity through Pauli and orbital limiting effects. However, there are rare instances of magnetic-field-induced superconductivity, as seen in Chevrel phase compounds [1], organic conductors [2], uranium-based heavy-fermion systems [3, 4], and moire graphene [5] though these materials possess inherently low superconducting transition temperatures (Tc). In this talk, I will present a high field-reentrant superconductivity in a class of materials with a significantly higher Tc: the infinite-layer nickelates [6, 7]. Both low-field and high-field superconducting states can be explained by a compensation mechanism akin to the Jaccarino-Peter effect. These findings highlight the technological potential of nickelates for ultra-high magnetic field applications such as superconducting magnets and quantum magnetometers.

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Suchitra Sebastian, *Cambridge University*

Title: TBD

Abstract: TBD

Qimiao Si, *Rice University*

Orbital-selective superconductivity: from Ruddlesden–Popper nickelates to twisted WSe_2

The discovery of superconductivity in the bilayer nickelate $La_3Ni_2O_7$—both in bulk form under high pressure and in thin films at ambient pressure—and related Ruddlesden-Popper nickelates have generated considerable interest. Here I address the effects of orbital-selective electron correlations —where some electronic orbital states experience stronger renormalization effects than others. We show how such effects influence the low-energy electronic structure [1,2] and electronic dynamics [2], and how they drive the superconducting pairing through both interlayer and intralayer exchange interactions [3]. Our findings compare well with experimental results, including spectroscopic measurements that shed light on the underlying correlation effects in the normal state as well as the measurements on the pairing gap structure in thin film bilayer systems at ambient conditions. For the latter, we especially highlight the role of orbital selectivity in determining the angular variation of the superconducting gap and the two-peak structure of the tunneling spectrum. The implications of this picture for the density wave order in the phase diagram is also discussed [4]. In the second part of the talk, I will describe how the superconductivity in such bulk settings could connect with what arise in moiré TMD systems. We show that topology and band flatness in these systems combine and yield a description in terms of compact molecular orbitals [5]. The resulting molecular-orbital-selective correlations give rise to superconductivity that is topological and chiral.

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Wolfgang Simeth, *Los Alamos National Laboratory*

Neutron spectroscopy on the heavy-fermion superconductor $CePd_2Si_2$

Low-energy excitations in correlated materials serve as the fingerprint of inherent quantum behavior and of emerging quantum states. Using high-resolution neutron spectroscopy, we studied magnetic excitations in $CePd_2Si_2$, a prototypical heavy-fermion material that becomes superconducting under pressure [1]. In the antiferromagnetic phase of $CePd_2Si_2$, the magnon spectra are well-described by the multi-orbital periodic Anderson model [2,3]. In addition, we observed a (nearly) non-dispersive excitation at ~1 meV that may account for the missing density of states and excess heat capacity that was earlier found in various Ce-based heavy-fermion materials [4]. Understanding the microscopic origin of these excitations may be important for the future understanding of $CePd_2Si_2$ and of unconventional superconductivity in general.

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Michael Smidman, *Zhejiang University*

Interplay of ferromagnetism and superconductivity in Ce-based heavy fermions

Although unconventional superconductivity is associated with antiferromagnetic quantum criticality, its relationship to ferromagnetic quantum phase transitions is less clear. While ferromagnetic quantum criticality has recently been revealed in Ce-based Kondo lattice materials [1,2], superconductivity at a ferromagnetic quantum critical point (QCP) has not yet been demonstrated.

Tuning Kondo ferromagnets often leads to a change of magnetic ground state instead of a ferromagnetic QCP. We find that superconductivity can occur in such a scenario in Ce_5CoGe_2 [3], which hosts non-collinear ferromagnetic order [4], but upon applying pressure there is a change from a ferromagnetic to antiferromagnetic ground state, before magnetism is suppressed at 3.2 GPa. Superconductivity emerges at pressures beyond this critical pressure, suggesting a distinct scenario for superconductivity in correlated materials, likely not purely associated with critical spin fluctuations. $CeSb_2$ is an unusual example of a pressure-induced heavy fermion superconductor, where the upper critical field greatly exceeds the Pauli limit, raising the prospect of triplet pairing. Despite there being several complex magnetic phases at ambient pressure, we find that the magnetic excitations show a striking one-dimensional nature, and can be well described by a ferromagnetic ladder model [5]. Importantly, diffuse excitations similar to those of the ordered phase persist well above the ordering temperature, suggesting that low-dimensional ferromagnetic paramagnons may significantly contribute to the unconventional superconductivity under pressure, underscoring the association of both quasi-one-dimensionality and ferromagnetism with possible triplet superconductivity.

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Jeff Sonier, *Simon Fraser University*

Muon spin rotation studies of the influence of chemical doping and hydrostatic pressure on UTe_2

The heavy-fermion compound UTe_2 is widely believed to host a rare spin-triplet superconducting state, though identification of the specific superconducting order parameter and the pairing mechanism remain unresolved. Muon spin rotation/relaxation (muSR) studies have made several contributions to the developed understanding of superconductivity in UTe_2, including evidence for ferromagnetic correlations [1], the occurrence of magnetic clusters in first-generation chemical vapor transport grown single crystals [2], the absence of spontaneous magnetic fields expected for a time-reversal symmetry breaking superconducting state [3], and relocalization of magnetic moments in the heavy Fermi-liquid state prior to the onset of superconductivity [4]. Recently our attention has shifted to investigating the influence of chemical doping and physical pressure on the magnetic and superconducting properties of UTe_2. Here I summarize the results of new muSR experiments on Th-doped UTe_2 and a collaborative muSR study of pure UTe_2 under hydrostatic pressure.

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Rina Tazai, *RIKEN*

Loop-Current-Induced Nematic and Chiral Superconductivity in Kagome Metals

Kagome metals AV_3Sb_5 (A = Cs, Rb, K) exhibit various symmetry-breaking phases, including charge-density-wave order, nematicity, loop-current order, and unconventional superconductivity. Recent experiments have revealed several puzzling superconducting properties, such as time-reversal-symmetry breaking, nematic gap anisotropy, and 2×2 pair-density modulation. Despite extensive studies, a unified theoretical understanding of these phenomena has remained elusive. In this work, we investigate superconductivity emerging in the loop-current phase of kagome metals. By solving the superconducting gap equation in a realistic kagome Hubbard model with coexisting loop-current and bond-order states, we demonstrate that loop-current order naturally stabilizes chiral superconductivity. The key mechanism is a coupling between the loop-current-induced orbital magnetization and the chirality of Cooper pairs, which lifts the degeneracy between opposite chiral pairing channels. Furthermore, when loop-current and bond-order states coexist, a nematic chiral superconducting state emerges even when the Fermi surface remains nearly C6 symmetric.

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Caitlin Tempelman, *Los Alamos National Laboratory*

Nonmagnon excitations in van der Waals beta-UTe_3

Van der Waals (vdW) materials are a frontier in condensed matter physics where genuine 2-D physics can be explored in the monolayer. Inclusion of actinide elements into vdW materials leads to enhanced correlations, unique magnetism, and potential unconventional superconductivity. beta-UTe_3 is an ideal candidate for probing such physics, having ferromagnetic order both in the bulk and monolayer limits with signs of 2-D correlations well-above the ferromagnetic transition. Here I will discuss advancements in the neutron scattering studies of beta-UTe_3. The observed magnetic excitations are gapless but remarkably non-magnon like, having a bandwidth of ~25 meV. We perform simulations of the magnetic scattering to set limits on the exchange interactions and indicate the interactions are strongly 2D. This work establishes the uniqueness of beta-UTe3 as a vdW magnet, providing a new material which can both be used in novel devices and whose reduced dimensionality can be leveraged for increased tractability of modeling 5f magnetism.

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Nathan Valadez, *Center of Integrated Nanotechnologies / University of Central Florida*

High-Resolution Time- and Angle-Resolved Photoemission Spectroscopy Capability at CINT User Facility

Time- and angle-resolved photoemission spectroscopy (Tr-ARPES) is a powerful technique for directly probing nonequilibrium electronic band structure and ultrafast phenomena in quantum materials. Unlike conventional angle-resolved photoemission spectroscopy (ARPES), which measures occupied electronic states in equilibrium, Tr-ARPES employs a pump-probe approach to visualize transient electronic states in both energy and momentum space. Here, we report a novel Tr-ARPES capability developed for the Center for Integrated Nanotechnologies (CINT) User Program. The system utilizes a highly efficient vacuum-ultraviolet (VUV) photon energy generated using highly cascaded harmonic generation (HCHG) in a Xe gas-filled negative-curvature hollow-core fiber, enabling photoemission measurements with an unprecedented energy resolution better than 20 meV and a combined pump-probe temporal resolution below 170 fs. The system operates at laser repetition rate of 250 kHz with high photon flux >10^12 photons/sec and power stability better than 5% RMS. The generated VUV harmonics range from 4.8 to 10.8 eV and pump energies from 0.2 to 2.0 eV. These features, together with automated harmonic selection using tunable monochromator, make the system versatile platform for investigating ultrafast electronic and quasiparticle dynamics in strongly correlated materials.

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Pedro Vianez, *Los Alamos National Laboratory*

Conventional superconductivity in heavy fermion superconductor $PrOs_4Sb_{12}$

Unconventional superconductors are of great interest due to their non-trivial order parameters and novel pairing mechanisms. $PrOs_4Sb_{12}$ is a heavy-fermion superconductor that has attracted significant attention due to its suggested time-reversal symmetry breaking, and complex gap structure. Here, we investigate the superconducting state of $PrOs_4Sb_{12}$ via AC calorimetry under uniaxial strain along the [100] and [110] crystallographic directions. We observe a quadratic suppression of the superconducting transition temperature Tc with strain, without any splitting of the transition, across all directions and samples. These results constrain the order parameter to the one-dimensional A1 representation, which is incompatible with previous observations of broken time reversal symmetry in $PrOs_4Sb_{12}$. Instead, superconductivity in $PrOs_4Sb_{12}$ can be understood as a cooperation between phonons and quadrupolar fluctuations, thereby presenting a cautionary example for interpreting signatures of broken time reversal symmetry as well as power laws in transport and thermodynamics as conclusive evidence for unconventional superconductivity.

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Pavel Volkov, *University of Connecticut*

Probing unconventional superconductors and inducing topology with twist

I will discuss the current status of the physics of twisted nodal and unconventional superconductors [1]. Twist transforms both the order parameter and the quasiparticle spectrum, leading to a rich phase diagram that includes time-reversal-breaking and topological states. In twisted bilayers of nodal superconductors, I will demonstrate how twist enables the emergence of topological superconductivity in the presence of current or magnetic field [1], while moiré superlattice may induce gapped nontopological phases [2]. Moreover, in finite-thickness flakes of nodal superconductors with N layers, current can be

used to generate new Dirac points and drive topological transitions with the number of edge modes scaling as N^2 [3]. Finally, properties of twisted interfaces between bulk superconductors can also be used to detect unconventional pairing, which I will illustrate with the examples of pair density wave [4] and time-reversal symmetry breaking [5] states.

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Jingyuan Wang, *Johns Hopkins University*

Reconciling strange metal transport in $CeCoIn_5$ through the difference of effective masses

The strange metal behavior in cuprate superconductors - characterized by linear in temperature resistivity and anomalous Hall transport - stands in stark contrast to the expectation of conventional Fermi liquid (FL) theory. Remarkably, the similar transport behavior has also been observed in the heavy fermion metal $CeCoIn_5$, whose d-wave superconducting ground state and strong antiferromagnetic fluctuations draw parallels to the cuprates. Here we have investigated the optical conductivity of the strange metal state of $CeCoIn_5$ over a wide magnetic field range using time-domain THz spectroscopy (TDTS). Using unique high-field THz spectroscopy we have shown that the current relaxation rate scales approximately as T^2, giving evidence for a hidden Fermi liquid state over a large field range. This result can be reconciled with linear in T resistivity with the realization that heavy quasiparticles have an optical mass that scales roughly like 1/T. This optical mass contrasts with the mass that characterizes cyclotron motion, which does not suffer the same large temperature dependent renormalization. Although by itself anomalous, this allows one to understand a number of other phenomena in $CeCoIn_5$ that have been taken to be signatures of strange metals, including the coexistence of a conventional T^2 dependence of the cotangent of the Hall angle with the linear in T resistivity, which with our observation also reflects FL-like physics.

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Stephen Wilson, *University of California, Santa Barbara*

Kagome metals as platforms for unconventional superconductivity

Kagome metals naively host multiple electron filling states where unconventional superconductivity is predicted to manifest. In this talk, I will discuss the latest picture of superconductivity and electronic order in the AV_3Sb_5 class of kagome metals, where signs of unconventional charge order intertwined with superconductivity manifest. If time permits, I will discuss anomalous charge density wave and superconducting phases in the kagome metals three-dimensional analogs, pyrochlore superconductors.

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Xinze Yang, *Yale University*

Quasiparticle Interference of Superconductivity and Sublattice Texture in CsV_3Sb_5

Probing the Momentum Structure of Superconductivity and Sublattice Texture via Quasiparticle Interference in the Kagome Material CsV_3Sb_5 Kagome lattices are theoretically proved to host quantum interference arising from the sublattice texture. This sublattice interference can induce nontrivial correlated quantum phases like unconventional superconductivity and chiral charge orders. Recently, the kagome material CsV_3Sb_5 has been found to exhibit the coexistence of both superconductivity and multiple charge density wave (CDW) phases at low temperature. This rich phase diagram makes it an appealing platform of investigating the interplay between superconductivity and CDW, as well as the rule of sublattice structure. However, the experimental research is challenged by the complicated multi-band Fermi surface and the small gap value (0.5meV), requiring detailed analysis of the band structure and high energy resolution spectroscopic measurement. In this work, we conducted sub-Kelvin scanning tunneling spectroscopy (STS) measurements of CsV_3Sb_5 with high energy resolution and sampling. We observed multiple quasiparticle interference (QPI) features, which, with the support of both ab inito calculation and tight binding analysis, are attributed to the scattering within the V Mz even band. Moreover, the k-q correspondence between the band structure and QPI features reveals that the superconductor gap in the V Mz even band is isotropic, thereby constrain any gap anisotropy to the V Mz odd band or Sb p band. Finally, based on the selective absence of certain QPI features, we conclude that the wave function on the Mz even Fermi surface does encode a sublattice texture.

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Wooin Yang, *University of Tennessee, Knoxville*

Revealing chiral d-wave pairing symmetry in Sn/Si(111) with tunneling Andreev reflection

A momentum-dependent complex order parameter characterizes chiral superconductivity with intrinsic phase winding, giving rise to nontrivial topology and unconventional quasiparticle interference. Chiral domain boundaries, where the superconducting phase varies spatially, are predicted to host localized topological bound states and time-reversal-symmetry breaking.

The Sn/Si(111) surface has been proposed as a strong candidate for chiral d-wave superconductivity, supported by scanning tunneling microscopy/spectroscopy evidence. A fully gapped but anisotropic superconducting state is a signature of topological edge states and possible time-reversal-symmetry breaking. Despite this compelling evidence, experimental exploration remains challenging because most spectroscopic probes are insensitive to the superconducting order parameter. In contrast, tunneling Andreev reflection (TAR), arising from coherent electron–hole scattering across a tunneling junction between a normal-metallic tip and a superconducting surface, probes both the amplitude and the phase of the superconducting order parameter. On the Sn/Si(111) surface, TAR directly probes the order parameter and reveals the pairing symmetry. Our results demonstrate that tunneling Andreev reflection spectroscopy can serve as a local probe of the superconducting order parameter for identifying chiral superconductivity.

Ruiqi Zhang, *Tulane University*

Magnetism-Enhanced Electron–Phonon Coupling in Cuprate and Nickelate Superconductors

Unconventional superconductors, especially cuprates and nickelates, have long fascinated the condensed-matter community because of their complex interplay among charge, spin, lattice, and orbital degrees of freedom. Despite decades of study, the microscopic origin of their anomalous normal-state properties and superconductivity remains unresolved. In particular, the role of electron–phonon coupling (EPC) has remained highly controversial: while strong electronic correlations and magnetic fluctuations are widely believed to be central, the extent to which phonons also contribute has been intensely debated.

In this talk, I will discuss how recent advances in first-principles calculations allow us to revisit this question from a new perspective. I will show that, when local magnetism is properly incorporated within advanced density functional theory, EPC in unconventional superconductors can be substantially stronger than previously believed. In hole-doped infinite-layer cuprates, our calculations reveal that magnetism dramatically enhances EPC and naturally reproduces the observed kink and peak–dip–hump features in the electronic spectra. Surprisingly, the dominant contribution does not arise from the conventionally emphasized oxygen-breathing modes, but instead from rotational oxygen phonons. I will then turn to infinite-layer nickelates, where a similar magnetic enhancement of EPC is found, although the dominant phonon channels are qualitatively different and are mainly associated with low-energy La and Ni vibrations coupled to flat Ni-$3d_{z2}$ bands. Together, these results suggest that EPC is not a negligible secondary effect in unconventional superconductors, but rather an important ingredient that can cooperate with magnetism and electronic correlations in shaping their low-energy physics. More broadly, this work points to a unified first-principles framework for understanding how lattice and magnetic degrees of freedom jointly influence emergent quantum materials.

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Ruoxi Zhang, *University of California, Santa Barbara*

Imaging the Meissner effect and local superfluid stiffness in a graphene superconductor

We report the observation of the Meissner effect in a rhombohedral graphene superconductor, realized via direct imaging of the static fringe magnetic field. In our few-micron sample, the onset of superconductivity manifests as a diamagnetic response that screens only ~100 ppm of the applied magnetic field. Tracking the evolution of the resulting nanotesla-scale fields in real space allows us to observe the entry of superconducting vortices and map the local superfluid stiffness, ρs. Correlating fringe field signals from both Meissner screening and magnetically ordered states, we show that superconductivity onsets in the midst of a continuous quantum phase transition to a canted spin ferromagnet. Within the superconducting state, we find the temperature dependence of ρs to be incompatible with isotropic Bardeen-Cooper-Schrieffer theory and the zero-temperature stiffness ρ0s to be linearly proportional to Tc, constraining future theoretical models of superconductivity in this system.