PCSI
Room Ballroom South - Session PCSI-SuA
Exotic Forms of Magnetism

Moderator: Scott Crooker, Los Alamos National Laboratory

3:30pm **PCSI-SuA-1 Magnon-Exciton and Magnon-Photon Couplings in CrSBr**, ***Eunice Bae,*** Cornell University **INVITED**

Magnon-based hybrid quantum systems are promising candidates for quantum interconnects and quantum sensors, and they offer a rich platform for exploring nonlinear magnonics and cavity–photon interactions. Two-dimensional (2D) van der Waals magnets provide a compact, atomically flat geometry that can be easily integrated into existing quantum circuits, such as superconducting resonators and qubits. Among various 2D magnets, the magnetic semiconductor CrSBr is particularly unique due to its strong spin–exciton [1, 2], spin–lattice [3], and magnon–exciton [4] interactions. In this presentation, I will first discuss magnon-exciton coupling despite their energetical mismatch by orders of magnitude. I will then discuss our recent work demonstrating coherent coupling between antiferromagnetic magnons in CrSBr and microwave photons in a niobium-based-on-chip resonator [5]. This work demonstrates the first step toward integrating layered van der Waals 2D magnets into superconducting microwave circuits, with full access for both microwave and optical probing. Finally, I will discuss how these properties of magnetic semiconductors can be harnessed for spintronic devices and quantum information science.

[1]Wilson, Nathan P., et al. "Interlayer electronic coupling on demand in a 2D magnetic semiconductor." Nature Materials 20.12 (2021): 1657-1662.

[2]Brennan, Nicholas J., et al. "Important elements of spin-exciton and magnon-exciton coupling." ACS Physical Chemistry Au 4.4 (2024): 322-327.

[3]Bae, YounJue, et al. "Transient magnetoelastic coupling in CrSBr." Physical Review B 109.10 (2024): 104401.

[4]Bae, YounJue, et al. "Exciton-coupled coherent magnons in a 2D semiconductor." Nature 609.7926 (2022): 282-286.

[5]Tang, J., Singh, A., Brennan, N., Chica, D., Li, Y., Roy, X., Rana, F., Bae, Y.J., Coherent Magnon-Photon Coupling in the Magnetic Semiconductor, 2025, Nano Lett., 25, (2025),10912-10918.

4:10pm **PCSI-SuA-9 Developing Tkinter-Based Application for Processing Electrical Transport Data Measured in Pulsed Magnetic Fields**, ***Gabriel Ruiz,*** Los Alamos National Laboratory

Pulsed magnetic fields provide access to extreme field regimes that are essential for probing quantum phenomena and characterizing complex material behaviors. However, their rapid field ramping introduces substantial measurement challenges, particularly the emergence of large Faraday-induced voltages in electrical transport setups. These unwanted voltages, arising from thetime derivative of themagneticflux, can exceed the intrinsicsample signal by ordersof magnitude and result in misleading asymmetries between the up-sweep and down-sweep of the magnetic field. This artifact not only distorts critical features such as quantum oscillations and resistive transitions but also complicates post-experimental analysis. To address this issue, we developed a Python-based software tool equipped with a graphical user interface(GUI) using the Tkinter library. The program enables users to automatically correct for the Faraday-induced voltage component by leveraging the inherentant isymmetry of the induced sign al between rising and falling field sweeps. It applies a least-squares fitting algorithm to extract normalization coefficients ($A_x$and A_Y) that best describe the proportional contribution of the induced signal in each voltage channel.These coefficients are then used to reconstruct and subtract the unwanted induced voltage component, yielding clean, symmetrized transport data. The GUI design prioritizes accessibility, allowing experimentalists with no programming experience to process their data through a point-and-click interface. Applied to real datasets from pulsed high-field measurements, the tool demonstrated excellent performance in recovering the true voltage response of materials, reducing up/down-sweep discrepancies to within noise levels. By removing the inductive artifact, the program clarifies transport signatures, improves interpretability, and enables consistent analysis across datasets.This tool significantly enhances the workflow efficiency and measurement fidelity for condensed matter researchers utilizing pulsed field environments.

4:15pm **PCSI-SuA-10 Giant Chiral Magnetoelectric Oscillations in a van der Waals Multiferroic**, ***Xinyue Peng,*** *Frank Gao,* UT Austin*; Xinle Cheng, Emil Viñas Boström,* Max Planck Institute for the Structure and Dynamics of Matter, Germany*; Dongseob Kim,* UT Austin*; Ravish Jain,* Academia Sinica, Taiwan*; Deepak Vishnu,* National Tsing Hua University, Taiwan*; Kalaivanan Raju,* Academia Sinica, Taiwan*; Raman Sankar,* Academia sinica, Taiwan*; Shang-Fan Lee,* Academia Sinica, Taiwan*; Michael Sentef,* Max Planck Institute for the Structure and Dynamics of Matter, Germany*; Takashi Kurumaji,* Caltech*; Xiaoqin Li,* UT Austin*; Peizhe Tang, Angel Rubio,* Max Planck Institute for the Structure and Dynamics of Matter, Germany*; Edoardo Baldini,* UT Austin

Helical spin structures are expressions of magnetically induced chirality, entangling the dipolar and magnetic orders in materials. The recent discovery of helical van der Waals multiferroics down to the ultrathin limit raises prospects of large chiral magnetoelectric correlations in two dimensions. However, the exact nature and magnitude of these couplings have remained unknown so far. Here we perform a precision measurement of the dynamical magnetoelectric coupling for an enantiopure domain in an exfoliated van der Waals multiferroic. We evaluate this interaction in resonance with a collective electromagnon mode, capturing the impact of its oscillations on the dipolar and magnetic orders of the material with a suite of ultrafast optical probes. Our data show a giant natural optical activity at terahertz frequencies, characterized by quadrature modulations between the electric polarization and magnetization components. First-principles calculations further show that these chiral couplings originate from the synergy between the non-collinear spin texture and relativistic spin–orbit interactions, resulting in substantial enhancements over lattice-mediated effects. Our findings highlight the potential for intertwined orders to enable unique functionalities in the two-dimensional limit and pave the way for the development of van der Waals magnetoelectric devices operating at terahertz speeds.

Reference:

Gao, F.Y., Peng, X., Cheng, X. *et al.* Giant chiral magnetoelectric oscillations in a van der Waals multiferroic. *Nature*632, 273–279 (2024). https://doi.org/10.1038/s41586-024-07678-5

4:20pm **PCSI-SuA-11 Enhanced-Entropy Phases in Geometrically Frustrated Pyrochlore Magnets**, ***Prakash Timsina,*** *Ludi Miao,* New Mexico State University

Frustrated magnets host unconventional states stabilized by degeneracy and entropy, from spin ice [1] to quantum spin liquids [2] and pyrochlore oxides [3]. Pyrochlore iridates $R_2Ir_2O_7$ (R = Dy, Ho) provide a platform with tunable *d-f* exchange interactions and multiple frustrated phases [3,4]. In these systems, competing interactions suppress long-range order, yielding emergent quasiparticles such as magnetic monopoles [1].

Using Monte Carlo simulations, we map the thermodynamic phase diagram, identifying the 2-in–2-out (2I2O) spin ice, fragmented 3-in–1-out/1-in–3-out (3I1O/1I3O) [4], and all-in–all-out (AIAO) ground states [5]. In this talk, we will investigate the two finite-temperature enhanced-entropy (EE) phases near phase boundaries, characterized by high entropy, strong susceptibility, and mixed spin configurations. These phases are found to be stabilized by entropy-driven free-energy minimization, with distinct behavior of specific heat capacity decoupling from susceptibility serving as key signatures [5] (Fig. 1 in PDF). These EE states define a new class of entropy-stabilized magnetic phases, underscoring the role of frustration in finite-temperature correlated states and offering pathways for entropy-based material design.

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[2] C. Broholm, R. J. Cava, S. A. Kivelson, D. G. Nocera, M. R. Norman, and T. Senthil, Science **367**, 263–273 (2020).

[3] J. S. Gardner, M. J. P. Gingras, and J. E. Greedan, Rev. Mod. Phys. **82**, 53 (2010).

[4] E. Lefrancois, V. Cathelin, E. Lhotel, J. Robert, P. Lejay, C.V. Colin, B. Canals, F. Damay, J. Ollivier, B. Fak, L. C. Chapon, R. Ballou, and V. Simonet, Nat. Commun. **8**, 209 (2017).

[5] P. Timsina, A. Chappa, D. Alyones, I. Vasiliev, and L. Miao, arXiv:2505.13352 (submitted: PRB, 2025).

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Author Index

Bold page numbers indicate presenter

— B —
Bae, Eunice: PCSI-SuA-1, **1**
Baldini, Edoardo: PCSI-SuA-10, 1
— C —
Cheng, Xinle: PCSI-SuA-10, 1
— G —
Gao, Frank: PCSI-SuA-10, 1
— J —
Jain, Ravish: PCSI-SuA-10, 1
— K —
Kim, Dongseob: PCSI-SuA-10, 1
Kurumaji, Takashi: PCSI-SuA-10, 1
— L —
Lee, Shang-Fan: PCSI-SuA-10, 1
Li, Xiaoqin: PCSI-SuA-10, 1
— M —
Miao, Ludi: PCSI-SuA-11, 1
— P —
Peng, Xinyue: PCSI-SuA-10, **1**
— R —
Raju, Kalaivanan: PCSI-SuA-10, 1
Rubio, Angel: PCSI-SuA-10, 1
Ruiz, Gabriel: PCSI-SuA-9, **1**
— S —
Sankar, Raman: PCSI-SuA-10, 1
Sentef, Michael: PCSI-SuA-10, 1
— T —
Tang, Peizhe: PCSI-SuA-10, 1
Timsina, Prakash: PCSI-SuA-11, **1**
— V —
Viñas Boström, Emil: PCSI-SuA-10, 1
Vishnu, Deepak: PCSI-SuA-10, 1