

PCSI

Room Ballroom - Session PCSI-SuA

Magnetism, Altermagnets, & Spin Phenomena

Moderator: Matthew Brahlek, Oak Ridge National Laboratory

3:30pm PCSI-SuA-1 Controlling Magnetism in RuO₂ through Strain and Surface Engineering, **Jong Seok Lee**, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

INVITED

Altermagnetism has recently emerged as a distinct class of magnetic order that combines key characteristics of ferromagnets and antiferromagnets. Its compensated antiparallel spin structure, intertwined with crystallographic rotational symmetry, gives rise to momentum-dependent spin splitting and unconventional magnetic responses, offering new opportunities for next-generation spintronic applications. Despite these intriguing properties, direct observation and control of the altermagnetic order remain challenging. In particular, the magnetic ground state of RuO₂, one of the most intensively studied candidate altermagnets, remains under active debate due to conflicting experimental observations.

In this presentation, I will discuss two complementary approaches to stabilizing and controlling altermagnetism in RuO₂: anisotropic strain engineering in thin films and chemical modulation of surface electronic states. In epitaxial RuO₂ films, anisotropic strain provides a means to modify the structural and electronic environment governing magnetic order, enabling control of the altermagnetic state. Beyond strain engineering, carrier doping offers another route to stabilizing compensated magnetic order. We show that modification of the surface chemical state of RuO₂ can induce a distinct surface magnetic state while leaving the bulk largely unaffected. Surface-sensitive X-ray photoemission spectroscopy, optical second-harmonic generation, and Kerr effect imaging reveal pronounced temperature-dependent changes and domain formation in oxygen-containing-species-modified RuO₂, in clear contrast to stoichiometric RuO₂. These observations indicate the emergence of surface magnetism associated with chemically induced electronic modulation. Together, our results demonstrate that both lattice strain and surface electronic engineering provide effective pathways for manipulating magnetism in RuO₂, highlighting the importance of structural and electronic degrees of freedom in understanding its debated magnetic ground state and providing new opportunities for nanoscale altermagnetic spintronics.

4:00pm PCSI-SuA-7 UPGRADED: Molecular Beam Epitaxy of Hybrid Heterostructures Interfacing an Altermagnet (CrSb) with a 2D Ferromagnet (CrTe₂) and a Topological Insulator (Sb₂Te₃), **Sandra Santhosh**, Kalana Halanayake, Soumyanil Adhikary, Supriya Ghosh, Anthony Richardella, Danielle R. Hickey, K. Andre Mkhoyan, Nitin Samarth, Pennsylvania State University

Altermagnetism is a theoretical classification of magnetic materials exhibiting a unique coexistence of long range antiferromagnetic order and non-relativistic spin-polarized electronic band structure. NiAs-type CrSb in the bulk is theoretically and experimentally categorized as a metallic altermagnet at room temperature with g-wave symmetry. We recently reported the molecular beam epitaxy (MBE) of thin films of epitaxial CrSb on insulating SrTiO₃(111) substrates via a buffer layer of topological Sb₂Te₃, using angle resolved photoemission spectroscopy (ARPES) and polarized neutron reflectometry to verify the altermagnetic nature of these films [1]. Here, we discuss a detailed comparison of the MBE growth of CrSb on insulating SrTiO₃(111) using two different buffer layers, Sb₂Te₃ and CrTe₂. Reflection high energy electron diffraction, X-ray diffraction, and transmission electron microscopy confirm the epitaxial growth of good quality films of NiAs-type CrSb (0001) in both cases. We also use *in vacuo* angle resolved photoemission spectroscopy at room temperature to verify the g-wave symmetric altermagnetic band splitting in 10 nm thick CrSb films grown on both types of buffer layers. *Ex situ* transport measurements reveal the absence of an anomalous Hall effect at room temperature, as expected theoretically from a g-wave altermagnet without additional broken symmetry. We discuss how the synthesis of these hybrid heterostructures that interface a room temperature altermagnet with topological insulators and 2D magnets provides a promising platform for novel spintronics devices.

Acknowledgements

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References

1. S. Santhosh *et al.*, *Adv. Mater.* **37**, e08977 (2025)

4:15pm PCSI-SuA-10 First- Principles Study of Strain- Controlled Magnetism in MnBi₂Se₄ Heterostructure, **Narendra Phulara**, University of Kansas, Nepal

Abstract :We present a first-principles study of the magnetic ground state of the magnetic quantum material MnBi₂Se₄ supported on a ferroelectric substrate. Using density functional theory, we will first compare ferromagnetic and antiferromagnetic configurations of freestanding MnBi₂Se₄. We will then obtain a fully relaxed slab structure of the ferroelectric substrate, construct the MnBi₂Se₄/substrate heterostructure, and determine its equilibrium geometry and magnetic ground state. Finally, shear strain will be applied to the relaxed heterostructure to examine how structural deformation modifies the relative stability of the ferromagnetic and antiferromagnetic states. This systematic study will establish whether shear strain provides an effective route for controlling the magnetic ground state of MnBi₂Se₄ in ferroelectric-based heterostructures for potential spintronic applications.

4:20pm PCSI-SuA-11 Investigating Magnetocaloric Properties of NdGaO₃, **Gabriel Ruiz Ruiz**, Los Alamos National Laboratory

NdGaO₃ is a rare-earth perovskite oxide that undergoes antiferromagnetic ordering below ~1.2 K. It is widely used as a substrate for the epitaxial growth of high-quality high-temperature superconducting thin films, including cuprates and the recently discovered nickelates. However, the intrinsic magnetic and magnetocaloric properties of the substrate can significantly influence measurements of these superconductors, particularly in high magnetic fields under adiabatic conditions, such as those employed at the pulsed Field Facility of National High Magnetic Field Laboratory (NHMFL). To evaluate the role of the substrate, we investigated the low-temperature magnetic and magnetocaloric properties of NdGaO₃ through magnetization measurements.

We observe clear antiferromagnetic ordering below 1.2 K and a large magnetic entropy change arising from field-induced suppression of magnetic disorder. These results demonstrate that NdGaO₃ exhibits a pronounced magnetocaloric effect at low temperatures. Consequently, the substrate can undergo substantial temperature changes during pulsed-field experiments, potentially affecting the measured response of superconducting nickelate thin films. These findings underscore the importance of accounting for the magnetocaloric behavior of NdGaO₃ when interpreting low-temperature, high-field measurements of superconducting heterostructures. With this research we strive to extract the magnetization, phase transition and magnetocaloric effect from NdGaO₃.

4:25pm PCSI-SuA-12 High-Efficiency Spin-to-Charge Conversion of Ultra-thin Mn₃Al/W Capping Layers on PLD Grown YIG, **Manisha Dabla**, Sanskriti Kaushik, Pushpendra Kumar, Jawaharlal Nehru University, India; **Prashant Kumar**, Motilal Nehru College, India; **Bijoy K Kuanr**, Jawaharlal Nehru University, India

Ultra-Low-Power Spin-Orbit Torque (SOT) switching for next-generation Magnetic Random Access Memory (SOT-MRAM) is the result of high interfacial spin mixing conductance, which guarantees that any spin current generated in the heavy metal or through spin-momentum locking can seamlessly cross into the noncollinear antiferromagnet. This study investigates the enhancement of spin transport properties and magnetization dynamics in pulsed laser deposition (PLD) grown structures of GGG/YIG(20nm)[S-1], GGG/YIG(20nm)/Mn₃Al(2nm)[S-2] and GGG/YIG(20nm)/Mn₃Al(2nm)/W(5nm)[S-3]. Utilizing broadband ferromagnetic resonance (FMR), we evaluate the impact of the ultra-thin noncollinear antiferromagnet, Mn₃Al on YIG and the effect of heavy-metal Tungsten, W capping on spin pumping efficiency derived from Gilbert damping (a) from FMR linewidths (DH). The pure YIG film [S-1] exhibits an intrinsically low a (0.0015) for our PLD-grown films. Upon deposition of Mn₃Al(2nm) layer, a significant increase in the DH and hence enhanced effective damping a_{eff} (0.0027) are observed. This enhancement is attributed to the injection of a pure spin current from the precessing YIG layer into the Mn₃Al layer via spin pumping, which was confirmed by almost same zero-frequency DH₀ and AFM measured rms roughness. The spin transport efficiency is further amplified in the S-3 trilayer with enhanced a_{eff} (0.0041). The addition of the 5 nm W layer, known for its large spin Hall angle, acts as a highly efficient spin sink that maximizes the spin current gradient across the interfaces. Consequently, the calculated real part of the interfacial spin mixing conductance demonstrates a progressive and substantial enhancement from bilayer (5.9 × 10¹⁷ m⁻²) and trilayer

($1.25 \times 10^{18} \text{m}^{-2}$) configurations. These findings reveal that integrating W layers in addition to an ultra-thin Mn_3Al on the PLD-grown YIG significantly optimizes spin interfacial transparency, offering critical insights for the development of low-power, YIG-based spintronic/magnonic devices.

Figure 1 Caption Here

Figure 2 Caption Here

[1] I. Sinha, P. Kumar, A. Pandey, Bijoy K. Kuanr and S. Manna; Phys Rev. B **112**, 224428 (2025).

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edges and domain walls, that act as anharmonic confining potentials. This behavior is confirmed experimentally (Figure 1). We measure the expected nonlinear power-law scaling of amplitude, a systematic shift toward larger wavevector excitations at higher harmonic order, and a spin-selective response indicative of an increasingly chiral harmonic stray field. These results provide a microscopic understanding of magnonic harmonic generation and highlight its potential for engineering nonlinear functionality in magnonic systems.

[1] A. J. D'Addario, K. Hu, M. W. Olszewski, D. C. Ralph, M. E. Flatté, K. C. Nowack, and G. D. Fuchs, arXiv:2603.14082 (2026)

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4:30pm PCSI-SuA-13 Strain and Defect-Tailored Magnetotransport in Ferrimagnetic Spinel NiCo_2O_4 Thin Films and Freestanding Membranes,
Qiuchen Wu, Yuanyuan Zhang, Tianlin Li, Department of Physics and Astronomy & Nebraska Center for Materials & Nanoscience, University of Nebraska–Lincoln; **Myung-Geun Han,** Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory; **Soo-Yoon Hwang, Yeon-Seo Nam,** Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory; Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH); **Si-Young Choi,** Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH), Republic of Korea; **Yimei Zhu,** Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory; **Xia Hong,** Department of Physics and Astronomy & Nebraska Center for Materials & Nanoscience, University of Nebraska–Lincoln

The ferrimagnetic spinel NiCo_2O_4 (NCO) is a promising material for designing high-performance spintronic devices, while epitaxial strain and disorder can significantly modify its electronic and magnetic properties [1–3]. Here, we use epitaxial NCO thin films and freestanding NCO membranes as model systems to reveal the complex roles of strain and defects in determining its metallicity and magnetotransport [4]. Epitaxial 30 nm NCO films are deposited on spinel MgAl_2O_4 and perovskite SrTiO_3 and LaAlO_3 substrates. Freestanding NCO membranes are achieved by depositing 30 nm NCO film on $\text{Sr}_3\text{Al}_2\text{O}_6$ buffered LaAlO_3 followed by water etching. The NiCo_2O_4 films on MgAl_2O_4 show metallic behavior, small linear magnetoresistance (MR) with weak temperature dependence, and strong perpendicular magnetic anisotropy. In contrast, NCO on perovskite substrates and freestanding NCO membranes show insulating behaviors that can be well described by the contributions from thermal activation, nearest-neighbor hopping, and 3D variable range hopping. MR and anomalous Hall studies point to the existence of phase separation and spin canting in these samples, which is corroborated by electron microscopy studies. Comprehensive anisotropic magnetoresistance (AMR) studies show that NCO films on MgAl_2O_4 exhibit two-fold sinusoidal AMR, which can be well described by coherent rotation model. Additional four-fold AMR component emerges in the insulating samples, which can be attributed to disorder-induced spin scattering and strain-induced tetragonal magnetocrystalline anisotropy. It is noted that the NCO membrane exhibits highly consistent magnetotransport properties as the $\text{NiCo}_2\text{O}_4/\text{Sr}_3\text{Al}_2\text{O}_6$ film, showing that water etching does not alter the strain and disorder level in the system. Our study provides effective material strategies for engineering spin transport and magnetic anisotropy in NCO and presents a promising venue for designing flexible magnetic memory, sensor, and spintronic applications.

[1] Chen et. al., Adv. Mater. **31**, 1805260 (2019).

[2] Chen et. al., Appl. Phys. Lett. **120**, 242401 (2022).

[3] Xu et. al., J. Appl. Phys. **132**, 020901 (2022).

[4] Wu et. al., ACS Nano **20**, 11008 (2026).

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4:35pm PCSI-SuA-14 Imaging the Harmonic Generation of Magnons,
Gregory Fuchs, Cornell University **INVITED**

This work examines the mechanisms underlying the harmonic generation of magnons [1]. Harmonic generation is a nonlinear process that is well known in nonlinear optics, where a strong pump excitation frequency ω can generate tones at 2ω , 3ω , 4ω etc. I will describe our experiments imaging the harmonic generation of magnons in a $\text{Ni}_{81}\text{Fe}_{19}/\text{Pt}$ microstrip using a scanning nitrogen-vacancy (NV) center microscope. We analyze these measurements in a nonlinear spin-wave framework that is directly analogous to harmonic generation in nonlinear optics. Within this framework, the harmonic response arises from nonlinear magnetization dynamics localized at strongly inhomogeneous textures, such as the sample

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