



# 2025 年自旋电子研讨会 Spin Summit 2025

## 会议手册 Conference Program Book

2025.08.04 - 09

Guiyang, Guizhou, China

**Organizers:** School of Physics, Nanjing University,  
College of Physics, Guizhou University,  
Guizhou Physical Society

## Conference Overview

Spin Summit 2025 is the 4<sup>th</sup> workshop of the Spin Summit series focusing on the fundamental and applied aspects of magnetism and spintronics. The workshop sessions will cover recent advances in magnetic materials, spin structures, devices, and dynamics, among others.

The meeting will take place from August 4-August 9, 2025 in Guiyang, Guizhou Province, China, which is far away from noisy metropolitan areas and an ideal location for escaping the heat wave at the height of summer.

The aim of the workshop is to promote effective and mutually beneficial interactions among participants with plenty of formal and informal discussion time. Spin Summit 2025 provides a platform to share your esteemed work with a diverse audience of your peers. We believe that your expertise and scientific standing will add significant value to the success of Spin Summit 2025. Please note that all expenses associated with travel, registration and accommodation at discounted rates will be covered by the participants.

**Time:** August 4<sup>th</sup> - 9<sup>th</sup>, 2025

**Venue:** Dacheng Jingshe Hotel, Guiyang, Guizhou, China

### **Organizing Committee:**

Di Wu 吴镒 (Chair) - Nanjing University

Tao Yu 于涛 (Co-Chair) - Huazhong University of Science and Technology

Peng Yan 严鹏 - University of Electronic Science and Technology

Jiang Xiao 肖江 - Fudan University

Haiming Yu 于海明 - Beihang University

**Contact us:** Beibei Zhan (战倍倍) 18685366119, [bbzhan@gzu.edu.cn](mailto:bbzhan@gzu.edu.cn)

Mengjie Bu (步梦洁) 18018797484, [bumj@nju.edu.cn](mailto:bumj@nju.edu.cn)

## Spin Summit 2025 Conference Schedule, August 4<sup>th</sup> - 9<sup>th</sup> 2025, Guiyang, Guizhou, China

	Monday (August 4th)	Tuesday (August 5th)	Wednesday (August 6th)	Thursday (August 7th)	Friday (August 8th)	Saturday (August 9th)
Morning 08:30-12:00	Arrival and Registration	Morning Session Discussion Leader: Kailun Yao Gerrit Bauer WanJun Jiang Gyungchoon Go Group photo taken / Coffee break Yizhou Liu Ji Zou	Morning Session Discussion Leader: Gerrit Bauer Guoqiang Yu Ka Shen Qi Wang Coffee break Jianqiang You Axel Hoffmann	Morning Session Discussion Leader: Di Wu Xixiang Zhang Yihong Wu Geun-Hee Lee Coffee break Bingfeng Miao Xuepeng Qiu	Morning Session Discussion Leader: Peng Yan Teruo Ono Jianhao Chen Coffee break Shilei Zhang Hongxin Yang	Departure
Afternoon 13:30-17:30		Afternoon Discussion (Free Time)	Afternoon Discussion (Free Time)	Poster Session	Afternoon Session Discussion Leader: Ke Xia Akashdeep Kamra Dingfu Shao Coffee break Hiroto Adachi Junxue Li Closing Remark	
Evening 19:00-21:30	Evening Opening Session Discussion Leader: Jiang Xiao Yaroslav Tserkovnyak Canming Hu	Evening Session Discussion Leader: Jin Lan Jian Shen Hyunsoo Yang Yuyan Wang	Poster Session	Evening Session Discussion Leader: Jin Tang Xiangrong Wang Ke Xia Ping Tang		

Program	
Monday, Day 1	
Second Floor Jiandao Hall, Dacheng Jingshe Hotel	
08:00-17:00	Arrival and Registration All Day
17:30-18:50	Dinner: Basement First Floor Western Restaurant, Hotel
Evening Opening Session Discussion Leader: Jiang Xiao	
19:00-19:05	<i>Fangyi Liang (Guizhou University)</i> Host of the Opening Ceremony
19:05-19:10	Vice President of Guizhou University
19:10-19:15	<i>Jiang Xiao (Fudan University)</i> Spin Summit 2025 Introduction
19:15-19:50	<i>Yaroslav Tserkovnyak (University of California, Los Angeles)</i> Quantum magnonics via color centers
19:50-20:25	<i>Canming Hu (University of Manitoba)</i> Nonreciprocal Control of the Speed of Light Using Cavity Magnonics
20:25-21:30	Evening Discussion

Tuesday, Day 2	
Second Floor Jiandao Hall, Dacheng Jingshe Hotel	
Morning Session	
Discussion Leader: Kailun Yao	
08:30-09:05	<i>Gerrit Bauer (Kavli Institute for Theoretical Sciences)</i> Selected topics on magnons and ferrons
09:05-09:40	<i>Wanjun Jiang (Tsinghua University)</i> Compensated ferrimagnets for emerging spintronics
09:40-10:15	<i>Gyungchoon Go (Korea Advanced Institute of Science and Technology)</i> Magnon Scalar Spin Chirality Hall effect
10:15-10:45	Group Photo Taken / Coffee Break
10:45-11:20	<i>Yizhou Liu (High Magnetic Field Laboratory, Chinese Academy of Sciences)</i> Construction of single hopfions and hopfion crystals
11:20-11:55	<i>Ji Zou (University of Basel)</i> Quantum computing and information transmission with mobile domain wall textures on racetracks
12:00-13:30	Lunch: Basement First Floor Western Restaurant, Hotel
13:30-17:30	Afternoon Discussion / Free Time
17:30-18:50	Dinner: Basement First Floor Western Restaurant, Hotel
Evening Session	
Discussion Leader: Jin Lan	
19:00-19:35	<i>Jian Shen (Fudan University)</i> Spintronics for neuromorphic computing
19:35-20:10	<i>Hyunsoo Yang (National University of Singapore)</i> Spin devices for nonvolatile memories, unconventional computing, and energy harvesting
20:10-20:45	<i>Yuyan Wang (Tsinghua University)</i> Nonlinear Hall Effect in Altermagnets
20:45-21:30	Evening Discussion

Wednesday, Day 3	
Second Floor Jiandao Hall, Dacheng Jingshe Hotel	
Morning Session	
Discussion Leader: Gerrit Bauer	
08:30-09:05	<i>Guoqiang Yu (Institute of Physics, Chinese Academy of Sciences)</i> Interaction Between Magnons in Magnetic Thin Films
09:05-09:40	<i>Ka Shen (Beijing Normal University)</i> Magnon Transport in Rare-Earth Iron Garnets
09:40-10:15	<i>Qi Wang (Huazhong University of Science and Technology)</i> Magnonic bistability and applications
10:15-10:45	Coffee Break
10:45-11:20	<i>Jianqiang You (Zhejiang University)</i> From quantum magnonics to quantum nonlinear magnonics
11:20-11:55	<i>Axel Hoffmann (University of Illinois Urbana-Champaign)</i> Hybrid Magnon Modes
12:00-13:30	Lunch: Basement First Floor Western Restaurant, Hotel
13:30-17:30	Afternoon Discussion / Free Time
17:30-18:50	Dinner: Basement First Floor Western Restaurant, Hotel
19:00-21:30	Poster Session

Thursday, Day 4	
Second Floor Jiandao Hall, Dacheng Jingshe Hotel	
Morning Session	
Discussion Leader: Di Wu	
08:30-09:05	<i>Xixiang Zhang (King Abdullah University of Science &amp; Technology)</i> Orbital Current-Induced Magnetization Switching and Its Application in Spin-Orbit Torque MRAM
09:05-09:40	<i>Yihong Wu (National University of Singapore)</i> Harness spin in ferromagnets for efficient magnetization switching and THz emission
09:40-10:15	<i>Geun-Hee Lee (Korea Advanced Institute of Science and Technology)</i> Unique characteristics of orbital current
10:15-10:45	Coffee Break
10:45-11:20	<i>Bingfeng Miao (Nanjing University)</i> Distinguishing the Spin Current Origin with Spin-charge Inter-conversion Measurements
11:20-11:55	<i>Xuepeng Qiu (Tongji University)</i> Manipulation of spin current polarization
12:00-13:30	Lunch: Basement First Floor Western Restaurant, Hotel
13:30-17:30	Poster Session
17:30-18:50	Dinner: Basement First Floor Western Restaurant, Hotel
Evening Session	
Discussion Leader: Jin Tang	
19:00-19:35	<i>Xiangrong Wang (The Chinese University of Hong Kong, Shenzhen)</i> Unified Theory of Unusual Anisotropic Magnetoresistance and Unidirectional Magnetoresistance in Nanoscale Bilayers
19:35-20:10	<i>Ke Xia (Southeast University)</i> Multipole moments in magnetic layered system
20:10-20:45	<i>Ping Tang (Tohoku University)</i> Longitudinal Spin Hall Magnetoresistance from Spin Fluctuations
20:45-21:30	Evening Discussion

Friday, Day 5	
Guizhou University	
Morning Session	
Discussion Leader: Peng Yan	
08:45-09:00	Take the shuttle bus to Guizhou University
09:00-09:35	<i>Teruo Ono (Kyoto University)</i> Superconducting diode effect
09:35-10:10	<i>Jianhao Chen (Peking University)</i> Spin caloritronic devices with magnon-flat bands and spin-spin correlations
10:10-10:40	Coffee Break
10:40-11:15	<i>Shilei Zhang (ShanghaiTech University)</i> Floquet Topological Pump via a Spin Ratchet
11:15-11:50	<i>Hongxin Yang (Zhejiang University)</i> Dzyaloshinskii-Moriya interaction: First-principles calculations, Materials, and its application for MRAM
12:00-13:30	Lunch: Guizhou University Restaurant



Afternoon Session	
Discussion Leader: Ke Xia	
13:30-14:05	<i>Akashdeep Kamra (RPTU in Kaiserslautern)</i> Antiferromagnetic magnon pseudospin: dynamics, diffusive transport, and quantum fluctuations
14:05-14:40	<i>Dingfu Shao(Institute of Solid State Physics, Chinese Academy of Sciences)</i> Antiferromagnetic tunnel junctions: Fundamental Principles of Reading and Writing
14:40-15:00	Coffee Break
15:00-15:35	<i>Hiroto Adachi (Okayama University)</i> Manifestation of Neel order-parameter fluctuations in the antiferromagnetic spin transport
15:35-16:10	<i>Junxue Li (Southern University of Science and Technology)</i> Experimental investigation of magnon spin relaxation and magnon-polaron in uniaxial antiferromagnetic insulators
16:10-16:40	Closing Remark
17:00-18:30	Dinner: Guizhou University Restaurant
18:30-21:30	Take the shuttle bus to Hotel / Free Time

## Poster Session

1	Shangyuan Wang 王上元	Stabilization and manipulation of topological spin textures with three-dimensional Dzyaloshinskii-Moriya interaction
2	Yihang Duan 段懿航	Magnon hybridization in easy-axis ferrimagnets
3	Yutian Wang 王昱天	Anatomy of spin wave polarization and its connection to dissipation
4	Mengying Guo 郭梦莹	Magnonic neuron
5	Yunwen Liu 刘允文	Alternating Spintronics: Capacitive Behavior of Spin Valves and Resonator Applications
6	Zhiping Xue 薛治平	Directional entanglement of spin-orbit locked nitrogen-vacancy centers by magnons
7	Zidong Wang	Terahertz-frequency oscillator driven by spin-orbit torque in NiF2/Pt bilayers
8	Jing Guo	Skyrmion diverter based on symmetric multi-layer system driven by spin-orbit torque
9	Jiongjie Wang 王炯杰	Simulation_of_antiferromagnetic_dipole_exchange_spin_wave_dispersion_relations
10	Jiale Peng 彭家乐	Theoretical Study on Magnetic Damping Properties Near Compensation Point of Ferrimagnetic Insulators
11	Chongzhou Wang	Interaction between Magnon Spin and Phonon Spin

12	Yunmei Li 李运美	Interplay between the topology and magnon-magnon interactions
13	Zi-an Wang 王子安	X-type stacking in cross-chain antiferromagnets
14	Shui-Sen Zhang 张水森	Deterministic Switching of the Néel Vector by Asymmetric Spin Torque
15	Jiahao Liu 刘佳豪	Evidence of Ultrashort Orbital Transport in Heavy Metals Revealed by Terahertz Emission Spectroscopy
16	Jinlong Wang	Broad-Wavevector Spin Pumping of Flat-Band Magnons
17	Qianqian Yang 杨倩倩	Domain wall depinning from a single notch in a synthetic ferrimagnetic nanoribbon
18	Haoran Chen 陈浩然	Six-fold angular-dependent magnetoresistance in four-fold Fe (001) films
19	Yang Cheng 程阳	Room-temperature magnetoelectric switching and magnetoelectric memory driven by gate voltage
20	Jintao Ke	Intrinsic Magnetocrystalline Anisotropy Induced Symmetry Dependent Field-Free Switching in Epitaxial Garnet Films
21	Shixuan Liang 梁诗萱	Field-free perpendicular magnetic memory driven by out-of-plane spin-orbit torques
22	Yichen Su	Sub-terahertz Spin Torque-Antiferromagnetic Resonance
23	Xiaoyu Wang 王啸宇	Large Tunneling Magnetoresistance in Nonvolatile 2D Hybrid Spin Filters

24	Yihui Jiang 蒋义挥	Current-Induced Generation and Long-Distance Motion of Skyrmions in Synthetic Antiferromagnetic Materials
25	Zhaozhuo Zeng 曾钊卓	Alignment-Dependent Gapless Chiral Split Magnons in Altermagnetic Domain Walls
26	Minghao Li 李明浩	Frequency comb in magnetic moire superlattices
27	Zian Xia 夏子安	Magnon Entanglement on Spin Chains
28	Tianci Gong 巩天赐	Absence of exceptional points for Damon-Eshbach magnons
29	Qianyin Ye 叶茜茵	Magnon Correlation Enables Spin Injection, Dephasing, and Transport in Canted Antiferromagnets
30	Bin Yang 杨斌	Extrinsic scattering induced magnon spin swapping effect in Bi-doped yttrium iron garnet
31	Hongbin Wu 武宏斌	Interplay between spin wave and domain wall in atomistic Kagome lattices
32	Yang Zhang 张扬	Magnonic radar for domain walls in synthetic antiferromagnets
33	Guibin Lan 兰贵彬	Coherent harmonic generation of magnons in spin textures
34	Yuqiang Wang	Ultrastrong to nearly deep-strong magnon-magnon coupling with a high degree of freedom in synthetic antiferromagnets

35	Zhejunyu Jin 金哲珺雨	Interaction-Driven Altermagnetic Magnon Chiral Splitting
36	Jilei Chen	Exploring antiferromagnetic magnons in the GHz frequency range
37	Long Li 李龙	Electrically writing a magnetic heliknoton in a chiral magnet
38	Wenkai Lou 娄文凯	Impurity scattering, magneto-optical and electromagnetic properties in staggered magnets
39	Ying Su 苏赢	Nonlinear Topological Acoustomagnonic and Acoustoelectric Responses
40	Hao Zhao 赵浩	Curvature induced Magnonic Frequency Combs
41	Jiacheng Liu 刘嘉诚	On-chip zero-field spin wave frequency multiplier and its application on qubit quantum control
42	Songquan Zhang 张淞铨	Magnetoelastic coupling induced acoustic wave reflection by a domain wall in synthetic antiferromagnets
43	Jie Pan 潘杰	Magnetoresistance Oscillations in Vertical Junctions of 2D Antiferromagnetic Semiconductor CrPS4

## Abstracts

### Lecture 1: Quantum magnonics via color centers

**Speaker:** Prof. Yaroslav Tserkovnyak

University of California, Los Angeles

**Abstract:** I will review our recent work that aims at harvesting quantum fluctuations of magnetic systems, with both quantum information and many-body physics in mind. Focusing on magnons as building blocks of collective spin dynamics in magnetic insulators, I will discuss the prospects of their scalable integration with proximal color centers, such as nitrogen-vacancy impurities, using the latter as either quantum sensors, which can be operated in a range of different physical modalities, or qubits, whose entangled dynamics is governed by the common dissipative magnonic environment. Recent experiments on using color centers as spectrally-resolved sensors of magnetic dynamics demonstrate their strong coupling with a range of 2D materials. Inspired in part by the ideas from quantum optics, we are now pursuing the inverse functionality: imprinting collective noise of the tunable environment onto emergent many-body properties of color-center ensembles.

### Lecture 2: Nonreciprocal Control of the Speed of Light Using Cavity Magnonics

**Speaker:** Prof. Canming Hu

University of Manitoba, Canada

**Abstract:** In this talk, I will explain the nonreciprocal physics of cavity magnonics [1], which has enabled non-reciprocal control of both the transmission amplitude [2] and the speed of light [3].

#### References

- [1] Babak Zare Rameshti, Silvia Viola Kusminskiy, James A. Haigh, Koji Usami, Dany Lachance-Quirion, Yasunobu Nakamura, Can-Ming Hu, Hong X. Tang, Gerrit E. W. Bauer, Yaroslav M. Blanter, *Physics Reports*, 979, 1-61 (2022).
- [2] Yi-Pu Wang, J.W. Rao, Y. Yang, Peng-Chao Xu, Y.S. Gui, B.M. Yao, J. Q. You, and C.-M. Hu, *Phys. Rev. Lett.* 123, 127202 (2019). (Editor's Suggestion).
- [3] Jiguang Yao, Chenyang Lu, Xiaolong Fan, Desheng Xue, Greg E. Bridges, and C.-M. Hu, *Phys. Rev. Lett.* 134, 196904 (2025). (Editor's Suggestion).

### Lecture 3: Selected topics on magnons and ferrons

**Speaker:** Prof. Gerrit Bauer

Kavli Institute for Theoretical Sciences

**Abstract:** The duality between electric and magnetic dipoles in electromagnetism only partly applies to condensed matter. This becomes evident when inspecting the elementary excitations of the magnetic and ferroelectric orders, viz. spin and polarization waves that are quantized into magnons and ferrons, respectively. Magnons are transverse Goldstone modes at GHz frequencies that carry magnetic dipoles, while ferrons (in displacive ferroelectrics) are longitudinal Higgs modes at THz frequencies that carry electric dipoles. The ferrons and magnons have received asymmetric attention from the condensed matter community in the past [1]: While magnonics is an established and flourishing subfield in magnetism at the brink of contributing to quantum information, ferronics is still non-existing but efforts are on the way to increase the popular interest [2]. I will review selected recent results on transport and spectral properties of magnons and ferrons.

#### References

[1] G.E.W. Bauer, P. Tang, R. Iguchi, J. Xiao, K. Shen, Z. Zhong, T. Yu, S.M. Rezende, J.P. Heremans, and K. Uchida, Perspective: Polarization transport in ferroelectrics, Phys. Rev. Applied 20, 050501 (2023).

[2] Ferrons and Magnons: Friends or Foes?  
<https://www.spice.uni-mainz.de/ferronics-vs-magnonics-home/>

#### **Lecture 4: Compensated ferrimagnets for emerging spintronics**

**Speaker:** Associate Prof. Wanjun Jiang

Tsinghua University

**Abstract:** Compensated ferrimagnet is an interesting material system that exhibits both magnetization and angular momentum compensation, which results in the chiral magnon transport, the fast spin dynamics and the ability to display topological spin textures with fast motion, amongst many others[1-2].

In this talk, I will first review the chiral magnon dynamics in one of the insulating compensated ferrimagnets Gd<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub>, in which I will show the electrical excitation and detection of chiral magnon dynamics in a Gd<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub>/Pt bilayer, by using the spin-torque ferromagnetic resonance, The physics behind can be attributed to the different temperature-dependent evolution of magnetization and angular momentum of the Gd and Fe sublattices[3].

In the second part, I will unravel unconventional spintronic behaviors in metallic rare-earth transition-metal (RE-TM) ferrimagnets. In particular, I will present the fast motion of compensated domain walls in Pt/CoGd/Ta trilayer for the ultrafast neuromorphic spintronic performances[4], together with the unprecedented spin torque switching of the extremely thick ferrimagnets with thickness up to 200 nm in Pt/FeGd/Ta trilayers[5]. In the end, the ability to electrically switch magnetization of metallic ferrimagnets in Pt/FeGd/Ta trilayers, by applying gate voltage by using an ionic liquid technique will be shown[6].

[1] Se Kwon Kim, et al., Nature Materials 21, 24-34(2022)

[2] Heng-An Zhou, et al., Journal of the Physical Society of Japan, 90, 081006(2021).

[3] Le-Dong Wang, et al., Phys. Rev. Lett. 133,166705(2024)

[4] Jiahao Liu, et al., Advanced Functional Materials, 2107870(2021)

[5] Teng Xu, et al., Under Review(2025)

[6] Yang Chen, et al., Phys.Rev. X, 15,011060(2025)

#### **Lecture 5: Magnon Scalar Spin Chirality Hall effect**

**Speaker:** Dr. Gyungchoon Go

Korea Advanced Institute of Science and Technology

**Abstract:** Scalar spin chirality, which quantifies the elementary noncoplanar spin configuration, plays a key role in the rich chiral physics exhibited by magnetic materials. However, previous studies have treated scalar spin chirality as a static quantity that plays only a passive role in a material's transport properties, leaving its band-dependent active transport behavior unexplored. In this talk, I show that scalar spin chirality itself undergoes a Hall-like flow in Kagome ferromagnets and antiferromagnets under external bias, a phenomenon termed the scalar spin chirality Nernst effect. Remarkably, this emerges without requiring spin - orbit coupling. We develop an analytical theory and validate it via atomistic spin simulations. These findings challenge conventional views, reveal dynamic roles for scalar spin chirality in chiral transport, and open routes to harness chiral signals in spintronic applications.

## **Lecture 6: Construction of single hopfions and hopfion crystals**

**Speaker:** Prof. Yizhou Liu

High Magnetic Field Laboratory, HFIPS, Chinese Academy of Sciences

**Abstract:** Hopfions are three-dimensional (3D) topological solitons characterized by the Hopf charge, representing a fascinating class of structures that bridge branches of physics across scales. These 3D configurations exhibit rich topology (including rings, links, and knots) and unique dynamical properties. In this talk, I will discuss the construction of single hopfions. Regarding the realization of single hopfions in real materials, we present a method to create stable magnetic hopfions on-demand in chiral magnetic nanocylinders. Our approach employs engineered trench structures activated by pulsed electrical currents. By precisely tuning current pulse amplitude and duration, we demonstrate deterministic control over hopfion topology and stability. Beyond single hopfions, I will also present a systematic approach for constructing hopfion crystals. We demonstrate simple cubic, face-centered cubic, and body-centered cubic hopfion crystals, and extend our framework to construct crystals of more complex topological structures, including axially symmetric tori, torus links, and torus knots with higher Hopf charges. These results provide a foundation for searching hopfions in real materials and studying their collective phenomena.

## **Lecture 7: Quantum computing and information transmission with mobile domain wall textures on racetracks**

**Speaker:** Prof. Ji Zou

University of Basel

**Abstract:** Topological spin textures, such as domain walls (DWs) and skyrmions, are fundamental to the field of spintronics, providing key components for classical information processing. Recently, we demonstrate that these mobile textures can also serve as a blueprint for large-scale quantum computers [1]. Their internal degrees of freedom, such as chirality, can be harnessed to encode quantum information. We use DWs to illustrate this idea. The DW qubit is highly versatile, functioning as both stationary and flying qubits capable of being shuttled at ultra-fast speeds. We also demonstrate this DW qubit on a quantum spin chain with DMRG simulation [2]. Furthermore, these mobile qubits enable long-range quantum information transmission [3]. Specifically, we consider a hybrid system consisting of distant spin qubits and a racetrack. By analyzing an explicit remote entanglement protocol, we find that the mobile textures can effectively transport quantum information between distant spin qubits in a highly controllable manner. These findings open the door to future explorations of topological spin textures for quantum information processing.

### **References**

- [1] Ji Zou, S. Bosco, B. Pal, S. Parkin, J. Klinovaja, D. Loss; Phys. Rev. Research 5 (3), 033166 (2023)
- [2] G. Qu, Ji Zou, D. Loss, T. Hirose; arXiv:2412.11585 (2024)
- [3] Ji Zou, S. Bosco, J. Klinovaja, D. Loss; arXiv:2409.14373 (2024)

## **Lecture 8: Spintronics for neuromorphic computing**

**Speaker:** Prof. Jian Shen

Fudan University

**Abstract:** In today's world, the rapid development of neural network models with artificial intelligence (AI) as the core, such as ChatGPT, has greatly changed people's lifestyles and ways of thinking. Although great success has been achieved, the energy consumption problems caused by



frequent data transmission between memory and processors have become increasingly prominent. In order to break through the current energy consumption bottleneck of intelligent computing, scientists are attempting to build new computing architectures and paradigms with higher energy efficiency based on physical systems. Among physical systems, the spin system has characteristics such as memory, nonlinearity, oscillation, randomness, and plasticity that are highly similar to those of the biological brain, making it a preferred system for constructing new neuromorphic computing architectures. We have made fruitful explorations in aspects such as reservoir computing, associative memory, and probabilistic computing by utilizing the spin system, laying an important foundation for the application of the spin system in future intelligent computing.

## **Lecture 9: Spin devices for nonvolatile memories, unconventional computing, and energy harvesting**

**Speaker:** Prof. Hyunsoo Yang

National University of Singapore

**Abstract:** Magnetic tunnel junction (MTJ)-based true random number generators (TRNGs) offer advantages over traditional CMOS-based TRNGs. We implement an MTJ-based TRNG, characterize the entropy of the raw output, and extract a set of random bits that are provably secure [1]. Nonlinear activation functions play a crucial role in artificial neural networks, and digital implementations of sigmoidal functions are facing challenges related to energy consumption and area requirements. To address these issues, we develop a proof-of-concept computing system that utilizes MTJs as the key element for implementing sigmoidal activation functions [2]. Using this system, we train a neural network for speech separation. Spin devices can offer alternative solutions for unconventional computing. We present an experimental Ising computer based on MTJs, which successfully solves a 70-city travelling salesman problem (4761-node Ising problem) [3]. By integrating the electrically connected eight spin-torque oscillators (STOs), we demonstrate a battery-free energy-harvesting system by utilizing the wireless RF energy to power electronic devices such as LEDs [4].

We present our perspective on spin device applications using emerging 2D materials. Previous proposals for field-free spin-orbit torque (SOT) switching of perpendicular magnetic anisotropy (PMA) require an additional magnetic field. Exploiting the out-of-plane spins could be a solution to this challenge [5]. Here we experimentally demonstrate field-free switching of PMA CoFeB at room temperature utilizing out-of-plane spins from Weyl semimetals, TaIrTe<sub>4</sub> [6] and PtTe<sub>2</sub>/WTe<sub>2</sub> [7]. Finally, we discuss magnon-mediated spin torques throughout an antiferromagnet, which could minimize Joule heating and corresponding energy dissipation [8].

### **References**

- [1] H. J. Ng, et al. Phys. Rev. Applied. 19, 034077 (2023).
- [2] Y. Bao, et al. Appl. Phys. Lett. 124, 242403 (2024).
- [3] J. Si, et al., Nat. Commun. 15, 3457 (2024).
- [4] R. Sharma et al., Nat. Elec. 7, 653 – 661 (2024).
- [5] Q. Yang, et al., Nat. Commun. 15, 1814 (2024).
- [6] Y. Liu, et al. Nat. Electron. 6, 732-738 (2023).
- [7] F. Wang, et al. Nat. Mater. 23, 768-774 (2024).
- [8] F. Wang, et al. Nat. Nano. 19, 1478 – 1484 (2024).

## Lecture 10: Nonlinear Hall Effect in Altermagnets

**Speaker:** Prof. Yuyan Wang

Tsinghua University

**Abstract:** Altermagnets are characterized by non-relativistic alternating spin splitting in the band structure and collinear compensated magnetic moments in real space.[1,2] Besides the direct detection of the altermagnetic spin splitting band, the observation of altermagnetic spin splitting torque and anomalous Hall/Nernst effect, as well as fine domain characterization were used to characterize altermagnets. Identifying distinct fingerprints of altermagnets is an ongoing and important task.

In this talk, I will present key fingerprints and experimental progress of altermagnets. I will begin with the observation of spin splitting torque in the altermagnet  $\text{RuO}_2$ , which serves as a clear fingerprint of altermagnetism and provides a unique opportunity for the non-relativistic generation of pure spin current.[3,4] Based on a universal asymmetric energy barrier model, the deterministic  $180^\circ$  switching of the Néel vector in  $\text{Mn}_5\text{Si}_3$  was achieved.[5] Furthermore, we show the manipulation of the altermagnetic order in  $\text{CrSb}$  via crystal symmetry, where the relative direction between the current-induced spin polarization and DM vector determines the switching modes of altermagnetic order.[6] Finally, I will introduce two types of nonlinear Hall effect (NLHE) in altermagnets: the magnetic NLHE (MNLHE) in  $\text{Mn}_5\text{Si}_3$  and third-order NLHE (TNLHE) in  $\text{RuO}_2$ . [7,8] MNLHE is characterized by a quadratic Hall conductivity dependence on magnetic field. This finding relies on an altermagnet,  $\text{Mn}_5\text{Si}_3$  thin film, whose alternating-sign Berry curvatures ensure higher-order MNLHE clearly distinguishable from the first-order AHE. MNLHE is non-analytic, as reversing the magnetic field flips the alternating spin-splitting bands and reverses the hopping chirality, which is absent in traditional NLHE. TNLHE is characterized by a cubic dependence of Hall voltage and current. TNLHE shows strong crystal orientation dependence, as it can only emerge when the experimental setup breaks all relevant mirror symmetries. Beyond offering distinctive transport fingerprints, NLHE opens up new opportunities for altermagnets in both fundamental research and engineering applications.

### References

- [1] C. Song, et al. Nat. Rev. Mater. DOI: 10.1038/s41578-025-00779-1 (2025).
- [2] Šmejkal, et al. Phys. Rev. X. 12, 040501 (2022).
- [3] H. Bai, et al. Phys. Rev. Lett. 128, 197202 (2022).
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## Lecture 11: Interaction Between Magnons in Magnetic Thin Films

**Speaker:** Prof. Guoqiang Yu

Institute of Physics, Chinese Academy of Sciences

**Abstract:** Investigating the interaction effects between magnons with different energies and modes not only lays the physical foundation for developing novel quantum devices but also provides a unique platform for revealing various novel physical phenomena. Consequently, exploring the mechanisms of magnon interactions has become a key scientific question in the field of magnonics. Our recent studies focus on magnon-magnon coherent coupling and nonlinear high-order interactions of magnons, with the main results summarized as follows:

In the study of magnon-magnon coherent coupling, we achieved room-temperature ultra-strong coupling in synthetic antiferromagnets (SAFs) with intrinsic asymmetry of magnetic anisotropy, including in-plane magnetized SAF, perpendicularly magnetized SAF, and T-type magnetized SAF. Theoretically, we described the magnon-magnon coherent coupling in SAF using a generalized Hopfield model and revealed the dependence of coupling strength on magnetic configurations. Experimentally, we achieved a near deep-strong coupling regime, with a normalized coupling strength reaching 0.963.

In the study of nonlinear high-order magnon interactions, we investigated three-magnon and four-magnon scattering and their high-order harmonic effects. Using diamond quantum sensing technology, we observed magnon high-order harmonic signals up to the 55th order in nickel-iron thin films. The study indicates that this phenomenon originates from the non-collinear magnetic structure at the sample edges, rather than dynamic flipping at magnetic domain boundaries. We demonstrated, for the first time, the excellent phase coherence of magnon high-order harmonics, laying the foundation for magnon-based information processing devices.

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## Lecture 12: Magnon Transport in Rare-Earth Iron Garnets

**Speaker:** Prof. Ka Shen

Beijing Normal University

**Abstract:** Spin waves or their quanta, magnons, in magnetic insulators are regarded as potential information carriers for low-consumption devices. As the spin wave properties in the star material, YIG (yttrium iron garnet), have been intensively investigated, other family members of rare-earth iron garnets have recently attracted increasing research interest partially because of the coexistence and the controllability of opposite magnon chiralities. In this talk, I would like to share our recent progresses on magnon transport in different rare-earth iron garnet systems. In particular, we will discuss the tunable spin Seebeck anomaly in two representative compensated ferrimagnetic garnets, GdIG (gadolinium iron garnet) [1-2] and TbIG (terbium iron garnet) [3-4], as well as the manifestation of magnon hybridization and chirality in spin pumping and spin-torque ferromagnetic resonance [5-7].

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## Lecture 13: Magnonic bistability and applications

**Speaker:** Prof. Qi Wang

Huazhong University of Science and Technology

**Abstract:** Magnonic bistability - a nonlinear phenomenon where spin-wave systems exhibit two stable amplitude states under identical excitation conditions - has emerged as a powerful tool for next-generation computing and signal processing [1-3]. In nanoscale magnetic waveguides, this bistability arises from strong nonlinear frequency shifts (up to 2 GHz in yttrium iron garnet) and thermal fluctuations, enabling deterministic or stochastic switching between states depending on system design. Recent advances have demonstrated its utility in all-magnonic logic gates, nonvolatile memory elements, and spin-wave repeaters that regenerate attenuated signals with phase normalization. Moreover, the inherent stochasticity of bistable switching has unlocked novel applications in true magnon random number generation (magnon-RNG), where probabilistic spin-wave excitation provides hardware-efficient, cryptographic-grade entropy.

This talk discusses the physics of magnonic bistability, including its dependence on waveguide geometry, material properties, and excitation protocols. We highlight key experimental demonstrations, such as GHz-frequency repeaters and magnon-RNGs with gigahertz bitrates, and discuss scalability challenges for integrated magnonic circuits. Finally, we outline future directions, including neuromorphic computing and probabilistic algorithms, where bistable magnonic systems could unlock unique computational paradigms rooted in wave-based physics. By bridging fundamental nonlinear dynamics with practical applications, magnonic bistability establishes a versatile framework for emerging non-von Neumann architectures.

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## Lecture 14: From quantum magnonics to quantum nonlinear magnonics

**Speaker:** Prof. Jianqiang You

Zhejiang University

**Abstract:** Quantum magnonics has emerged as a new direction of research in recent years. This talk focuses on some advancements of my group in this area. First, I will demonstrate the quantum control of a single magnon, including the deterministic generation of a single-magnon state and its coherent superposition with the vacuum (zero-magnon state). Second, I will present some new results on magnon squeezing in the quantum regime, so as to show our efforts to explore novel phenomena in quantum nonlinear magnonics.

## Lecture 15: Hybrid Magnon Modes

**Speaker:** Prof. Axel Hoffmann

University of Illinois Urbana-Champaign

**Abstract:** Magnons readily interact with a wide variety of different excitations, including microwave and optical photons, phonons, and other magnons. Such hybrid magnon dynamic

excitations have recently gained increased interest due to their potential impact on coherent information processing [1]. This in turn opens new pathways for hybrid quantum information systems [2 – 4]. I will discuss specific examples and strategies, where we developed fully integrated devices that form the essential building blocks for more complex integrated coherent quantum systems. Towards this end, we demonstrated strong magnon-photon coupling in scalable coplanar devices using coplanar superconducting microwave photon resonators [5]. Based on this concept we have shown how two magnon resonators can be coupled over macroscopic distances, and using local time-resolved detection, we demonstrate coherent, Rabi-like, energy exchange between them [6]. Conversely, photons in two separate coplanar waveguides can be transmitted in a directional manner via nonreciprocal coupling to magnons [7]. Lastly, I will show how a superconducting qubit can be used for sensitively detecting magnon populations over a broad dynamic range [8]. These measurements illustrate the potential of using magnons for coherently controlled interactions ultimately even in the single quantum limit.

This work was supported by the U.S. Department of Energy, Office of Science, Materials Sciences and Engineering Division under Contract No. DE-SC0022060.

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## Lecture 16: Orbital Current-Induced Magnetization Switching and Its Application in Spin-Orbit Torque MRAM

**Speaker:** Prof. Xixiang Zhang

King Abdullah University of Science & Technology (KAUST)

**Abstract:** The orbital Hall effect (OHE) has emerged as a promising mechanism for electrically controlling magnetization in thin-film ferromagnets. In this work, we design a compensated multilayer structure to isolate the orbital current contribution and experimentally demonstrate orbital-current-induced magnetization switching. By tailoring the multilayer configuration, we achieve polarity control of magnetization reversal and extract the orbital charge conversion efficiency. Furthermore, we integrate this mechanism into a spin-orbit torque magnetic random-access memory (SOT-MRAM) device, featuring a pinned reference layer and exhibiting robust switching behavior with high tunnel magnetoresistance. These results highlight the potential of orbital currents for advancing energy-efficient and scalable spintronic memory technologies.

## Lecture 17: Harness spin in ferromagnets for efficient magnetization switching and THz emission

**Speaker:** Prof. Yihong Wu

National University of Singapore

**Abstract:** The ability to electrically manipulate spin states in magnetic materials is fundamental to the development of energy-efficient spintronic devices. Traditionally, such control has been

realized in systems comprising a spin source and a magnetic target, where a charge current induced spin current alters the magnetic state of the latter. However, growing evidence now points to the potential of ferromagnets themselves to act as efficient spin sources. In this talk, I will present recent progresses in spin current generation within ferromagnets and the resulting phenomena, including anomalous.

Hall magnetoresistance, spin – orbit torque, and terahertz emission. The discussion will cover both single-layer and multilayer systems, including those involving non-collinear antiferromagnets and synthetic antiferromagnets. I will highlight how efficient magnetization switching and THz generation can be achieved in these systems without the need for heavy metals, offering promising directions for all-ferromagnet based spintronic technology.

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## Lecture 18: Unique characteristics of orbital current

**Speaker:** Dr. Geun-Hee Lee

Korea Advanced Institute of Science and Technology (KAIST)

**Abstract:** Spin-orbit torque (SOT) stands as a pivotal concept in spintronics, enabling fascinating applications like current-induced magnetization switching [1], magnetic soliton dynamics [2], and GHz oscillation [3]. Historically, SOT's origin was attributed to spin currents arising from the Rashba effect or the spin Hall effect. Yet, over the last decade, it's become clear that SOT is a combined effect of spin-orbit interaction (SOI) with either the orbital Rashba effect (ORE) [4] or the orbital Hall effect (OHE) [5].

The underlying mechanism is as follows: orbital current, generated through ORE or OHE, undergoes conversion into spin current via SOI, and this spin current is what ultimately produces SOT. While extensive research focuses on boosting the efficiency of SOT or orbital torque [6] by refining SOI and identifying materials that generate substantial orbital current [7, 8], there's still a gap in efforts to uncover the unique outcomes directly linked to orbital current itself, separate from SOT.

Our focus aims in on two specific aspects: orbital exchange interaction and orbital angular position (OAP) . Unlike conventional orbital torque, orbital exchange interaction [9] offers a direct pathway for interaction between orbital current and the orbitals of ferromagnets. Consequently, our theoretical findings reveal that orbital current alters magnetocrystalline anisotropy, magnetic damping, and the gyromagnetic ratio—effects that were not anticipated when solely considering spin current. We will outline two experimental approaches to validate our theoretical predictions.

OAP represents a degree of freedom for electron orbitals, distinct from spin, and corresponds to the shape of the wavefunction. Recently, it was discovered that orbital angular momentum (OAM) and OAP Hall current occur concurrently in a broad range of solids [10], although their physical consequences are expected to be quite different. We will discuss the distinct optical responses observed from accumulated OAM and OAP, and provide the formulas for the reflection coefficient in the presence of both OAM and OAP. Furthermore, we will present our recent experimental data demonstrating that the contributions from OAM and OAP can be systematically distinguished.

Our work illuminates the unique consequences of orbital current within conventional spin-orbitronic devices. Beyond this, our findings have the potential to extend to the control or detection of exotic materials, such as altermagnets, where electron orbitals play a pivotal role.

## **Lecture 19: Distinguishing the Spin Current Origin with Spin-charge Inter-conversion Measurements**

**Speaker:** Prof. Bingfeng Miao  
Nanjing University

**Abstract:** Spin current and the related spin-orbit torque are crucial for spintronic applications, including magnetic random access memory and spin current logic devices. Various methods have been reported to generate pure spin current, including the spin Hall effect, interface Rashba-Edelstein effect, spin splitting effect etc. Typically, these mechanisms induced phenomena are very similar thus distinguishing them is not straightforward.

Recently, we have developed systematic methods to distinguish different spin-charge conversion mechanisms based on the symmetry analysis and the reciprocal relation of the spin-charge inter-conversion. We identified the Rashba-Edelstein effect in Ag/Bi-ferromagnetic metal interface and solved the debate about the spin transport picture in Ag/Bi interface [1], isolated the anisotropic spin Hall effect and spin splitting effect contributions in RuO<sub>2</sub> [2], observed the anomalous spin Hall effect in Py and realized field-free switching of perpendicularly magnetized YIG with the z-polarized spin current [3].

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## **Lecture 20: Manipulation of spin current polarization**

**Speaker:** Prof. Qiu Xuepeng  
Tongji University

**Abstract:** In normal metal/ferromagnet heterostructures, transport of spin current generates spin orbit torque and drives efficient magnetization switching [1]. However, the spin current, arising from either the spin Hall effect or interface Rashba-Edelstein effect, is normally polarized along the y direction, i.e., in the film plane and transverse to the electric current direction as a  $\sigma_y$  component. This restriction fundamentally hinders the efficiency and requires external magnetic field for SOT switching of perpendicular magnetization. Here, we demonstrate that  $\sigma_z$  spin current arising from non-collinear antiferromagnetic Mn<sub>3</sub>Sn is more capable for efficient and field-free perpendicular magnetization switching [2]. The magnetic origin of such  $\sigma_z$  spin current has been further elucidated in altermagnetic RuO<sub>2</sub> through an unconventional spin Hall magnetoresistance [3]. Furthermore, we demonstrate the generation of both  $\sigma_x$ ,  $\sigma_y$ ,  $\sigma_z$  spin currents through nontrivial geometric rotation of spin transport plane by wedge thickness or anisotropic conduction design. The corresponding spin orbit torque have been found of distinctly different vector symmetry and magnetization switching dynamics. The continuous tuning of  $\sigma_z/\sigma_y$  ratio and anisotropic field-free spin orbit torque switching have been also realized.

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## **Lecture 21: Unified Theory of Unusual Anisotropic Magnetoresistance and Unidirectional Magnetoresistance in Nanoscale Bilayers**

**Speaker:** Prof. Xiangrong Wang

The Chinese University of Hong Kong, Shenzhen

**Abstract:** Nanoscale bilayers consisting of at least one magnetic layer exhibit universal unusual anisotropic magnetoresistance (UAMR) and unidirectional magnetoresistance (UMR). They are currently understood through various mechanisms related to the interconversion of charge current and spin current, giant magnetoresistance, thermal magnonic effects, thermoelectric effects, and diverse spin dependent scattering processes. This raises a fundamental question: do the universal behaviours observed in a wide range of systems stem from underlying general principles? We demonstrate here that both UAMR and UMR arise from electron transport influenced by the magnetization vector present in the magnetic material and the interfacial potential inherent in heterostructures. Specifically, UAMR represents current-independent resistance (resistivity) of bilayers. UMR is the resistance proportional to the current although electron transports of the bilayers are the linear response to high current densities and their induced thermal gradients. Our theory introduces a novel approach that considers the interplay between the magnetization vector, thermal gradients, and the effective internal electric field at the interface. This framework provides a unified explanation for both UMR and UAMR, effectively capturing key experimental features such as dependence on current direction, magnetization orientation, film thickness, and magnetic field strength. Furthermore, it offers a universal perspective that bridges UMR and UAMR effects, enhancing our understanding of spin-dependent transport phenomena in bilayers.

## **Lecture 22: Multipole moments in magnetic layered system**

**Speaker:** Prof. Ke Xia

Southeast University

**Abstract:** Multipole moments serve as order parameters for characterizing higher-order magnetic effects in momentum space, providing a framework to describe diverse magnetic responses including spin transport. In this talk, we introduce a methodology to quantitatively determine the octupole moment through angle-dependent anomalous Hall current, with explicit incorporation of discrete crystal symmetries. We find that the Hall current at the nonmagnetic metal | ferromagnetic metal interfaces is generally not perpendicular to Magnetization with only a few exceptions at high-symmetry crystal orientations. Our calculation illustrates the breakdown of  $\mathbf{j}_H = \theta_m \times \mathbf{j}_c$ . Additionally, we identify the presence of a chiral AHE at the interface with odd rotational symmetry (e.g.,  $C_{3v}$ ), and the higher-order terms can even dominate the AHE by constructing superlattices.

## **Lecture 23: Longitudinal Spin Hall Magnetoresistance from Spin Fluctuations**

**Speaker:** Prof. Ping Tang

Tohoku University

**Abstract:** Spin Hall magnetoresistance (SMR), the variation in resistance of a heavy metal (HM) with the magnetization orientation of an adjacent ferromagnet (FM), has been extensively studied as a powerful tool for probing surface magnetic moments in a variety of magnetic materials [1,2].



However, the conventional SMR theory assumes rigid magnetization of a fixed magnitude, an assumption that breaks down close to the FM's Curie temperature ( $T_c$ ), where the magnetic susceptibility diverges. Here, we report an unconventional SMR effect arising from the magnetic-field modulation of spin fluctuations in the FM, while its magnetization remaining collinear to the spin Hall accumulation in the HM. In contrast to the conventional SMR, which scales with the magnetization and vanishes near  $T_c$ , such “longitudinal” SMR (LSMR), though suppressed at low temperatures, becomes critically enhanced at  $T_c$ , reaching a magnitude comparable to conventional SMR amplitudes. Our findings offer a promising method for electrically detecting enhanced spin fluctuations in magnetic systems.

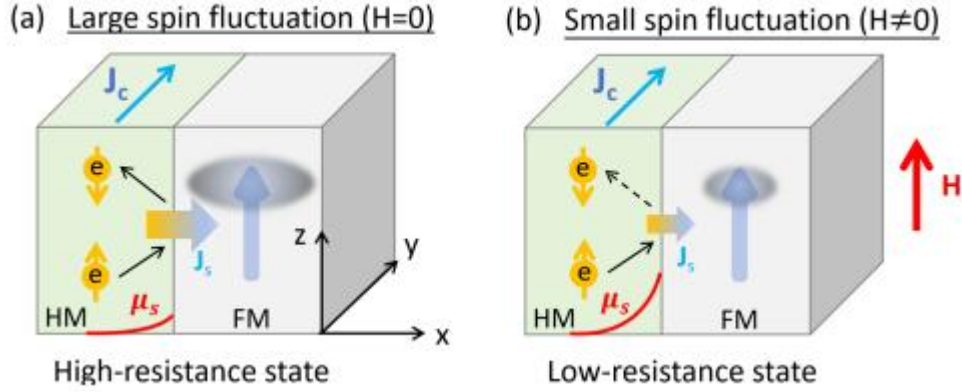


Fig. 1: Schematics for the proposed longitudinal spin Hall magnetoresistance in bilayers of a heavy metal and an insulating ferromagnet.

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## Lecture 24: Superconducting diode effect

**Speaker:** Prof. Teruo Ono

Kyoto University

**Abstract:** The diode effect is fundamental to electronic devices and is widely used in rectifiers and AC-DC converters. However, conventional diodes suffer from energy loss due to finite resistance. We found the superconducting diode effect (SDE) in Nb/V/Ta superlattices with a polar structure, which is the ultimate diode effect exhibiting a superconducting state in one direction and a normal state in the other [1-3]. The SDE can be considered as the nonreciprocity of the critical current for the metal-superconductor transition. We have also found the reverse effect, i.e., the nonreciprocal critical magnetic field under the application of supercurrent [4]. We also found that the polarity of the superconducting diode shows a sign reversal when the magnetic field is increased [5], which can be considered as the crossover and phase transitions of the theoretically predicted finite-momentum pairing states [6, 7]. SDE in Nb/V/Ta superlattices requires the application of an external magnetic field to break the time-reversal symmetry, which is a drawback in applications. Recently, we have succeeded in demonstrating zero-field SDE by introducing ferromagnetic layers into superlattices [8, 9]. The polarity of the SDE is controlled by the magnetization direction of the ferromagnetic layer, leading to the development of novel non-volatile memories and logic circuits with ultra-low power consumption.

This work was partly supported by JSPS KAKENHI Grant Numbers (18H04225, 18H01178, 18H05227, 20H05665, 20H05159, 21K18145), MEXT Initiative to Establish Next-generation

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## Lecture 25: Spin caloritronic devices with magnon-flat bands and spin-spin correlations

**Speaker:** Prof. Jianhao Chen

Peking University

**Abstract:** van der Waals magnets have been a fertile playground for low-dimensional spin excitation and spin-based device applications; spin-spin correlations in complex spin structures provide exotic correlated states that might facilitate spin excitation and transport. We will discuss our recent process in a long distance, quasi-1D magnon transport in a 2D spin lattice, aid by the formation of a flat magnon band; short introduction of an electrically operated digital magnon NOT gate[1] and an electrically operated magnon anisotropic read-only memory [2] will also be provided; lastly, we will discuss an ultra-long distance spin transport phenomena based on spin-spin correlation instead of conventional exchange interactions (Figure 1). These results unveil the potential of van der Waals anti-ferromagnets and complex magnetic materials for studying highly tunable spin physics and for application in magnon-base circuitry in future information technology.

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## Lecture 26: Floquet Topological Pump via a Spin Ratchet

**Speaker:** Prof. Shilei Zhang

ShanghaiTech University

**Abstract:** In chiral magnets, complex three-dimensional spin textures can emerge from competing interactions and geometric confinement. Among these, the recently discovered skyrmion screw lattice exhibits a unique modulation along the string axis, breaking axial symmetry and giving rise to new collective dynamics. When interlocked with conical spin orders, this configuration forms a composite state capable of supporting an emergent charge pump—a real-space analogue of the Thouless pump.

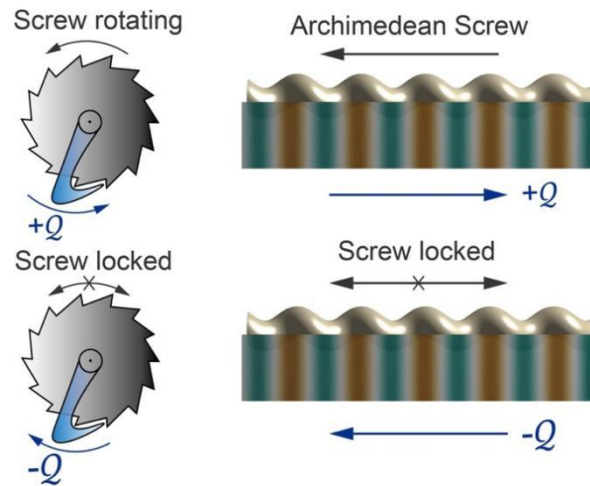


Fig. 1 The mechanism of the spin ratchet, enabling Floquet pumping.

In this talk, I will first introduce the Archimedean screw effect: a Goldstone mode in the conical phase that manifests as a MHz-scale translational motion of the entire spin structure. Then, I will demonstrate how periodic excitation of the so-called “+Q conical resonance” acts as a driving pawl in a magnetic ratchet system, coupling into the skyrmion screws and inducing a directional motion of the spin texture, as illustrated in the figure. Using advanced magnetic chronoscopy techniques, we resolve this dynamic in real time and show that each screw pitch advancement corresponds to the transport of emergent charge. This mechanism exemplifies Floquet-engineered topology in real space and offers a novel platform for dynamic control of spin textures in topological magnets.

## Lecture 27: Dzyaloshinskii-Moriya interaction: First-principles calculations, Materials, and its application for MRAM

**Speaker:** Prof. Hongxin Yang  
Zhejiang University

**Abstract:** Understanding the magnetic interactions is of fundamental importance in condensed matter physics as well as in the application of spintronic devices. In the last one and a half decades, the Dzyaloshinskii-Moriya interaction (DMI) has attracted increasing attention. Here, I will present a systemic survey of the first-principles calculations methods for DMI [1-3], along with an overview of the first-principles calculations of the DMI properties of typical material systems [4-6] and the DMI induced magnetic phenomena, e.g. skyrmions-based logic gates [7], DMI-torque switching of perpendicular magnetization [8] and Bimeron torque switching of in-plane magnetization[9].

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## **Lecture 28: Antiferromagnetic magnon pseudospin: dynamics, diffusive transport, and quantum fluctuations**

**Speaker:** Prof. Akashdeep Kamra

RPTU in Kaiserslautern

**Abstract:** In two-sublattice antiferromagnets, the magnonic spin excitations occur in pairs thereby admitting a new magnonic pseudospin degree of freedom. This shares some resemblance to the spin of an electron as well as polarization states of light, while constituting a unique embodiment of a bosonic mode pseudospin. The concept allows us to describe the full range of magnonic excitations, from spin-1 to spin-0, in antiferromagnets. In this manner, a general spin transport phenomenology in antiferromagnets is realized, similar to spin transport in electrons. The observation of magnon Hanle effect and its nonreciprocity can be well understood within this framework. This further allows us to envision spin transport phenomena and devices combining the positive aspects of magnons and electrons. Inspired by this recently demonstrated experimental control, we investigate the quantum fluctuations and control of this magnon pseudospin in a quest to examine its niche over spin squeezing realized with previous atomic ensembles and light-based platforms.

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## **Lecture 29: Antiferromagnetic tunnel junctions: Fundamental Principles of Reading and Writing**

**Speaker:** Prof. Dingfu Shao

Institute of Solid State Physics, HFIPS, Chinese Academy of Sciences

**Abstract:** Antiferromagnetic tunnel junctions (AFMTJs) hold great promise for spintronic devices with high operation speed, high storage density, and low power consumption. The realization of their information read/write functionality relies on achieving high tunneling magnetoresistance (TMR) and deterministic Néel vector switching. Through theoretical modeling, we reveal three distinct TMR mechanisms in AFMTJs based on 1) momentum-dependent spin splitting, 2) Néel spin currents, and 3) uncompensated interfacial spin-polarizations. Furthermore, we demonstrate the mechanism of deterministic Néel vector switching via asymmetric spin torque generated by current-induced non-identical spin accumulations between sublattices in collinear antiferromagnets. Overall, with these fundamental principles of reading and writing, AFMTJs

have potential to become a new standard for spintronics providing larger magnetoresistive effects, several orders of magnitude faster switching speed, and much higher packing density than conventional magnetic tunnel junctions.

## References

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## Lecture 30: Manifestation of Neel order-parameter fluctuations in the antiferromagnetic spin transport

**Speaker:** Prof. Hiroto Adachi

Research Institute for Interdisciplinary Science, Okayama University

**Abstract:** Spin transport has attracted much attention as a new probe of quantum materials [1], and the spin pumping as well as the spin Seebeck effect are established as convenient means to examine spin transport properties. Here, we argue that an unconventional exchange coupling (Neel coupling) at a spin uncompensated interface gives rise to a spin transport that manifests the Neel order-parameter fluctuations. First, we demonstrate that the Neel coupling brings about a divergent and strongly frequency-dependent enhancement of the spin pumping signal in a ferromagnet/antiferromagnet/heavy metal trilayer [2]. Second, we show that the Neel coupling may explain the convex-downward temperature dependence of the spin Seebeck effect near  $T_c$  observed in a ferrimagnetic/heavy metal bilayer [3].

## References

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- [3] K. Uchida et al., Phys. Rev. X 4, 041023 (2014).

## Lecture 31: Experimental investigation of magnon spin relaxation and magnon-polaron in uniaxial antiferromagnetic insulators

**Speaker:** Prof. Junxue Li

Southern University of Science and Technology

**Abstract:** Long-distance transport of magnon spin currents in antiferromagnetic (AFM) insulators is essential for the development of magnonics [1,2], however, their relaxation mechanisms remain unclear. Here, we report that the  $D'$ -yakonov-Perel'-type magnon spin relaxation mechanism governs the long-distance spin current transport in two prototypical uniaxial AFM insulators,  $\text{Cr}_2\text{O}_3$  and  $\alpha\text{-Fe}_2\text{O}_3$ . Three key pieces of evidence will be presented. (1) An over 450% enhancement of the first-harmonic non-local resistance induced by a magnetic field is observed prior to the spin-flop transition, which cannot be fitted by an established magnon-gap-closure model but is well-interpreted by our model incorporating  $D'$ -yakonov-Perel'-type magnon spin

relaxation. (2) We find that the magnon spin diffusion length in Cr<sub>2</sub>O<sub>3</sub> increases by 35% at 35 K, consistent with the D'yakonov-Perel'-type magnon spin relaxation model. (3) Temperature dependence of the zero-field magnon spin diffusion length in both AFM insulators can be qualitatively explained very well through our model.

At the same time, we will also show that phonon can also be used to tune the magnon spin relaxation in antiferromagnetic insulator Cr<sub>2</sub>O<sub>3</sub> through magnon-phonon hybridization. Clear signatures of the magnon-polaron in the second-harmonic non-local channel can be observed, which persists even after blocking the spin current on the non-local injection channel. The dependence of the magnon-polaron signal as a function of the magnetic field strength, angle, and temperature are systematically investigated.

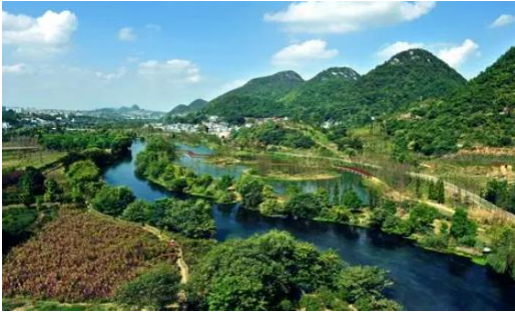
This work presents two promising approaches to effectively modulate the magnon spin relaxation, paving the way for applications that leverage long-distance spin current transport in AFM insulators.

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# 贵阳游玩推荐 (Guiyang Travel & Food Guide)

## 1、十里河滩 ( Shilihe Wetlands )



Ten miles of wetlands, Huaxi ‘Pearl of the Plateau’ of the ‘gem’, set of rivers, fields, reservoirs and ponds, rare species. In December 2009, it was promoted to National Urban Wetland Park.

十里河滩湿地，花溪“高原明珠”之“宝石”，集河田库塘，物种珍稀。2009年12月晋升国家城市湿地公园。

## 2、花溪公园 ( Huaxi Park )



Huaxi Park, the ‘Highland Poetry Corridor’ in the south of Guiyang. Flat bridge with blue water, a hundred steps on the waves, Linshan overlooking, hibiscus picnic, golden avenue autumn stained wutong. Wandering for half a day, one step is an epic, one glance is a scroll.

花溪公园，贵阳城南的“高原诗廊”。。平桥碧水、百步踏波、麟山俯瞰、黄金大道秋染梧桐。半日徜徉，一步一史诗，一眼一画卷。

## 3、青岩古镇 5A (Qingyan Ancient Town)



Qingyan: Ming stone citadel since 1378. Cobbled lanes breathe history, three faiths shine in one skyline, the south wall gazes across the Qian Mountains—one step into the past, one glance across a thousand years.

青岩古镇，洪武石城（1378年）；石巷史、三教辉、长城望黔山——一步入史，一眼千年。

## 4、花溪夜郎谷 ( Huaxi Yelang Valley )



Yelang Valley—stone epic on Huaxi River. In 1994, Song Peilun single-handedly carved a thousand-masked citadel and soaring monoliths from local rock. Whispered to be the palace of the Yelang king, its ancient garrison still stands.

夜郎谷——花溪畔的石头史诗。1994年，宋培伦独资开谷，垒出千面脸谱古堡、擎天石柱。传说为夜郎王行宫，古屯堡遗迹犹存。

### 路程 (Journey):





## 5、黔灵山公园 4A ( Qianlingshan Park )



Qianlingshan Park: at 1,396 m, Daluo Peak overlooks the city; 1,000-year-old Hongfu Temple shares the forest with wild macaques. Mirror-like Qianling Lake, Seven-Star Pools, and Kylin Cave complete the scene. In 2009, it was named a National Eco-Civilization Education Base.

黔灵山公园，1396米大罗岭，千年弘福寺与野生猕猴同林；黔灵湖，七星潭，麒麟洞。2009年评为国家生态文明教育基地。

## 6、花溪十字街 ( Huaxi Cross Street )



**推荐美食：**花溪牛肉粉，贵厨酸汤牛肉，树厨贵州黔菜，丝娃娃

**Recommended food:** Huaxi Beef Vermicelli, Guizhou Beef in Sour Soup, Tree Kitchen Guizhou Qian Cuisine, Silk Dolls

## 7、青云市集 ( Qingyun Market )



**推荐美食：**留一手特色烤鱼，胡佬陆铁签烤牛肉，珍珍水果豆花，各种小吃

**Recommended food:** Speciality Grilled Fish, Hu Luo Lu Roast Beef with Iron Stick, Zhen Zhen Fruit Bean Paste, Various Snacks

## 8、民生路好吃街 ( Minsheng Road Food Street )



**推荐美食：**臭豆腐、锅巴糍粑、米皮、脆哨、厕所馒头等特色小吃。

**Recommended food:** Stinky tofu, pot patties, rice skin, crispy whistles, toilet buns and other speciality snacks.

### 路程 (Journey):

