Spin Summit 2025

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Conference Overview

Spin Summit 2025 is the 4^{th} 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^{th} - 9^{th}, 2025

Venue: Dacheng Jinshe Hotel, Guiyang, Guizhou, China

Organizers: School of Physics, Nanjing University,

College of Physics, Guizhou University,

Guizhou Physical Society

Program	
2025.08.04，Monday，Day 1	
08:00-17:00	Arrival and Registration All Day
Evening Opening Session Discussion Leader: Jiang Xiao	
19:00-19:10	Jiang Xiao（Fudan University） Spin Summit 2025 Introduction
19:10-19:15	Guizhou University
19:15-19:50	Yaroslav Tserkovnyak (University of California, Los Angeles) Quantum magnonics via color centers
19:50-20:25	Canming Hu (University of Manitoba) Nonreciprocal Control of the Speed of Light Using Cavity Magnonics
20:25-21:30	Evening Discussion
2025.08.05，Tuesday，Day 2	
Morning Session Discussion Leader: Guoqiang Yu	
08:30-09:05	Gerrit Bauer (Kavli Institute for Theoretical Sciences) Selected topics on magnons and ferrons
09:05-09:40	Wanjun Jiang (Tsinghua University） Compensated ferrimagnets for emerging spintronics

09:40-10:15	Gyungchoon Go(Korea Advanced Institute of Science and Technology) Magnon Scalar Spin Chirality Hall effect
10:15-10:45	Group Photo Taken / Coffee Break
10:45-11:20	Yizhou Liu (High Magnetic Field Laboratory, Chinese Academy of Sciences) Construction of single hopfions and hopfion crystals
11:20-11:55	Ji Zou (University of Basel) Quantum computing and information transmission with mobile domain wall textures on racetracks
12:00-13:30	Lunch Time
13:30-17:30	Afternoon Discussion
17:30-19:00	Self-organized Dinner
Evening Session Discussion Leader: Yihong Wu	
19:00-19:35	Jian Shen (Fudan University) Spintronics for neuromorphic computing
19:35-20:10	Hyunsoo Yang (National University of Singapore) Spin devices for nonvolatile memories, unconventional computing, and energy harvesting
20:10-20:45	Yuyan Wang (Tsinghua University) Nonlinear Hall Effect in Altermagnets
20:45-21:30	Evening Discussion

2025.08.06，Wednesday，Day 3	
Morning Session Discussion Leader: Kailun Yao	
08:30-09:05	Guoqiang Yu (Institute of Physics, Chinese Academy of Sciences) Interaction Between Magnons in Magnetic Thin Films
09:05-09:40	Ka Shen (Beijing Normal University) Magnon Transport in Rare-Earth Iron Garnets
09:40-10:15	Qi Wang (Huazhong University of Science and Technology) Magnonic bistability and applications
10:15-10:45	Coffee Break
10:45-11:20	Jianqiang You（Zhejiang University） From quantum magnonics to quantum nonlinear magnonics
11:20-11:55	Axel Hoffmann (University of Illinois Urbana-Champaign) Hybrid Magnon Modes
12:00-13:30	Lunch Time
13:30-17:30	Afternoon Discussion
17:30-19:00	Self-organized Dinner
19:00-21:30	Poster Session
2025.08.07，Thursday，Day 4	
Morning Session	

Discussion Leader: Di Wu	
08:30-09:05	Xixiang Zhang (King Abdullah University of Science & Technology) Orbital Current-Induced Magnetization Switching and Its Application in Spin-Orbit Torque MRAM
09:05-09:40	Yihong Wu (National University of Singapore) Harness spin in ferromagnets for efficient magnetization switching and THz emission
09:40-10:15	Geun-Hee Lee (Korea Advanced Institute of Science and Technology) Unique characteristics of orbital current
10:15-10:45	Coffee Break
10:45-11:20	Bingfeng Miao (Nanjing University) Distinguishing the Spin Current Origin with Spin-charge Inter-conversion Measurements
11:20-11:55	Xuepeng Qiu (Tongji University) Manipulation of spin current polarization
12:00-13:30	Lunch Time
13:30-17:30	Poster Session
17:30-19:00	Self-organized Dinner
Evening Session Discussion Leader: Gerrit Bauer	
19:00-19:35	Xiangrong Wang (The Chinese University of Hong Kong, Shenzhen)

	Unified Theory of Unusual Anisotropic Magnetoresistance and Unidirectional Magnetoresistance in Nanoscale Bilayers
19:35-20:10	Ke Xia (Southeast University) Multipole moments in magnetic layered system
20:10-20:45	Ping Tang (Tohoku University) Longitudinal Spin Hall Magnetoresistance from Spin Fluctuations
20:45-21:30	Evening Discussion
2025.08.08，Friday，Day 5 **（Guizhou University）**	
Morning Session Discussion Leader: Yizheng Wu	
08:30-09:05	Teruo Ono (Kyoto University) Superconducting diode effect
09:05-09:40	Jianhao Chen (Peking University) Spin caloritronic devices with magnon-flat bands and spin-spin correlations
09:40-10:15	Hiroto Adachi (Okayama University) Manifestation of Neel order-parameter fluctuations in the antiferromagnetic spin transport
10:15-10:45	Coffee Break
10:45-11:20	Shilei Zhang (ShanghaiTech University)

	Floquet Topological Pump via a Spin Ratchet
11:20-11:55	Hongxin Yang (Zhejiang University) Dzyaloshinskii-Moriya interaction： First-principles calculations, Materials, and its application for MRAM
12:00-13:30	Lunch Time
Afternoon Session Discussion Leader: Tao Yu	
13:30-14:05	Akashdeep Kamra (RPTU in Kaiserslautern) Antiferromagnetic magnon pseudospin: dynamics, diffusive transport, and quantum fluctuations
14:05-14:40	Dingfu Shao(Institute of Solid State Physics, Chinese Academy of Sciences) Antiferromagnetic tunnel junctions: Fundamental Principles of Reading and Writing
14:40-15:15	Junxue Li (Southern University of Science and Technology) Experimental investigation of magnon spin relaxation and magnon-polaron in uniaxial antiferromagnetic insulators
15:15-16:00	Closing Remark

Poster Session		
1	Shangyuan Wang 王上元	Stabilization and manipulation of topological spin textures with three-dimensional Dzyaloshinskii-Moriya interaction
2	Yihang Duan	Magnon hybridization in easy-axis ferrimagnets
3	Yutian Wang 王昱天	Anatomy of spin wave polarization and its connetion 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	Yu Shuai 帅宇	Electrochemical reduction for modulating spin state of nickel: A pathway to improved water and seawater oxidation
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	Large Tunneling Magnetoresistance in Nonvolatile 2D

	王啸宇	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 twisted magnonic crystals
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		

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 qbits, 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).

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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

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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 dynamaics and the ability to display topological spin textures with fast motion, amongest many others[1-2].

In this talk, I will first review the chiral magnon dynamics in one of the insulating compensated ferrimagnets Gd3Fe5O12, in which I will show the electrical excitation and detection of chiral magnon dynamics in a Gd3Fe5O12/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-matal (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 unpresedent 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].

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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

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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, TaIrTe4 [6] and PtTe2/WTe2 [7]. Finally, we discuss magnon-mediated spin torques throughout an antiferromagnet, which could minimize Joule heating and corresponding energy dissipation [8].

References

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[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 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° switching of the Néel vector in Mn5Si3 was achieved.[5] Furthermore, we show the manipulation of the altermagnetic order in 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 Mn5Si3 and third-order NLHE (TNLHE) in RuO_2.[7,8] MNLHE is characterized by a quadratic Hall conductivity dependence on magnetic field. This finding relies on an altermagnet, Mn5Si3 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 emerges 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.

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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.

References

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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] .

References

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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: 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.

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Lecture 15: 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 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 RuO2 [2], observed the anamolus 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 Mn3Sn 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 RuO2 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 tunning 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 j_H =\theta m × jc, Additionally, we identify the presence of a chiral AHE at the interface with odd rotational symmetry (e.g., C3v), 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 (Tc), 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 Tc, such “longitudinal” SMR (LSMR), though suppressed at low temperatures, becomes critically enhanced at Tc, reaching a magnitude comparable to conventional SMR amplitudes. Our findings offer a promising method for electrically detecting enhanced spin fluctuations in magnetic systems.

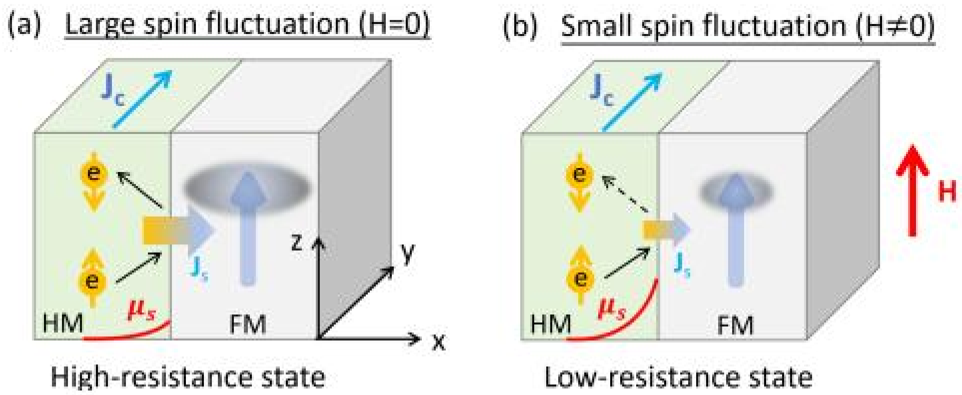

Fig. 1: Schematics for the proposed longitudinal spin Hall magnetoresistance in bilayers of a heavy metal and an insulating ferromagnet.

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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 Novel Integrated Circuits Centers (X-NICS) Grant Number JPJ011438, the Cooperative Research Project Program of the Research Institute of Electrical Communication, Tohoku University, and the Collaborative Research Program of the Institute for Chemical Research, Kyoto University.

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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: 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 Tc observed in a ferrimagnetic/heavy metal bilayer [3].

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Lecture 27: 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.

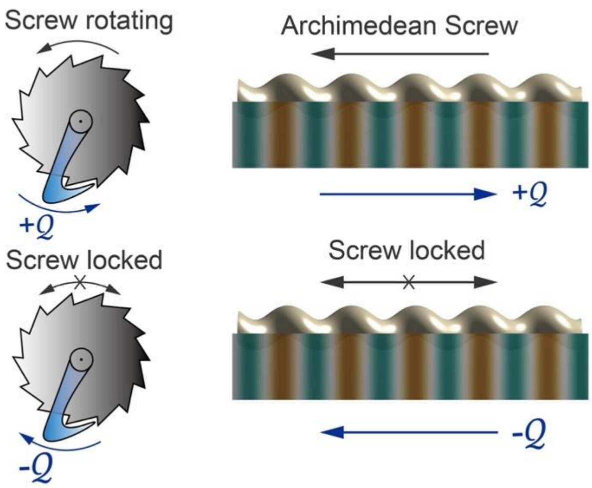

Fig. 1 The mechanism of the spin rachet, enabling Floquet pumping.

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 28: 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 29: 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 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 30: 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.

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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, Cr2O3 and alpha-Fe2O3. 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 Cr2O3 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 tune the magnon spin relaxation in antiferromagnetic insulator Cr2O3 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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