

第二届 稀土离子量子网络研讨会

会议手册

主办单位：

中国科学技术大学 量子网络安徽省重点实验室

安徽·合肥

2026年4月10日—4月13日

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组织机构

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主办单位：

中国科学技术大学

量子网络安徽省重点实验室

会议日程

会议时间：2026年4月10日-13日

会议地点：安徽合肥稻香楼宾馆，桂苑牡丹厅

April 10	
9:00-22:00	Registration
18:00-20:00	Buffet
April 11	
Moderator: Zong-Quan Zhou	
8:30-8:40	Welcome Speech, Chuan-Feng Li
8:40-9:10	Rare earth doped crystals for integrated quantum photonics Philippe Goldner Institut de Recherche Chimique de Paris
9:10-9:40	Exploring excited-state behavior in lanthanide-molecule nanohybrids San-Yang Han Tsinghua University
9:40-10:10	Rare Earth Photophysics Bin Dong Dalian Minzu University
10:10-10:55	Coffee Break, Group Photo & Posters
Moderator: San-Yang Han	
10:55-11:25	Quantum Teleportation from Telecom Photons to Erbium-Ion Ensembles Xiao-Song Ma Nanjing University
11:25-11:55	XingHan 2.0: A Metropolitan-scale Multiplexed Quantum Repeater with Bell Non-locality Zong-Quan Zhou University of Science and Technology of China

11:55-14:00	Lunch & Break
Moderator: Xiao-Song Ma	
14:00-14:30	A thermal-noise-resilient microwave quantum network up to 4 K You-Peng Zhong Southern University of Science and Technology
14:30-15:00	On-Chip Optical Memory Enabled by Bound States in the Continuum—A Silicon-Erbium Hybrid Platform Yu-Hui Chen Beijing Institute of Technology
15:00-15:30	Quantum state engineering of nuclear spins in solid-state systems based on the central spin model Heng Shen Shanxi University
15:30-16:10	Coffee Break & Posters
Moderator: Yu-Hui Chen	
16:10-16:40	Rare-earth Quantum Information: Vision, Status and Outlook Li-Gang Wang Peking University
16:40-17:10	Gravitational time dilation in quantum clock interferometry with entangled quantum memories Mustafa Gündoğan Humboldt-Universität zu Berlin
17:10-17:40	Probing local charge networks in a nano-transistor with a single erbium ion Chun-Ming Yin University of Science and Technology of China
17:40-18:00	The Paradigm Shift in Electrochemical Simulation: A Spin Episode under Non-Equilibrium Zhao-Ming Xia Ganjiang Innovation Academy
18:00-18:20	Design of Rare-Earth Complexes for Molecular Quantum Functional Materials You-Song Ding Ganjiang Innovation Academy
18:30	Welcome Banquet
April 12	
Moderator: Heng Shen	

8:30-9:00	Broadband light-matter interface at 1.5 μm Qiang Zhou University of Electronic Science and Technology of China
9:00-9:30	Spin properties of single Ce ions in LuAG crystal Kang-Wei Xia University of Science and Technology of China
9:30-10:00	Cold-atom based quantum networks: from many to single, then to many again Yong Yu University of Science and Technology of China
10:00-10:30	Coffee Break & Posters
Moderator: Qiang Zhou	
10:30-10:55	Heterogeneous entanglement between a trapped ion and a solid-state quantum memory Tian-Xiang Zhu University of Science and Technology of China
10:55-11:20	Storage of telecom-band time-bin qubits in thin-film lithium niobate Tian-Shu Yang Shanxi University
11:20-11:45	Optically Detected and Modulated Magnetic Resonance of Rare-Earth Ions Ye-Xin Wang Quantum Science Center of Guangdong-Hong Kong-Macao Greater Bay Area
11:45-12:10	Toward Telecom-Band Quantum Nodes Using Rare-Earth Stoichiometric Crystals Fu-Dong Wang Shenzhen International quantum Academy
12:10-14:00	Lunch & Break
14:00-17:00	Laboratory Tour
17:00	Buffet

Invited talks

Rare earth doped crystals for integrated quantum photonics

Philippe Goldner

Institut de Recherche Chimique de Paris

Systems with both spin and optical transitions offer a range of functionalities for technologies such as quantum communications, computing, and sensing. Among various solid-state systems currently considered, rare-earth doped materials stand out as they combine, at cryogenic temperatures, long-lived optical and spin quantum states. In addition, they offer optical transition in a wide spectral range, including telecom wavelengths, high chemical stability, and easy doping in many hosts, thus enabling using large ensembles of centers with uniform properties.

Quantum-grade rare earth doped nanostructured materials such as nanoparticles, thin films, or molecular crystals, aiming at integration into nanophotonics devices have recently raised a strong interest. In this talk, we will present some of our recent results in the field, as well as the challenges to be addressed to bring rare-earth doped materials up to the highly demanding requirements of quantum technologies.

Short Biography

Philippe Goldner

Philippe Goldner is a CNRS research director working at the Paris Institute for Chemical Research (Chimie ParisTech, CNRS, PSL University). In 1993, he obtained his PhD and joined the CNRS to work on luminescent rare earth doped materials. He later moved to the French National Center for Telecommunication Studies and in 2002 to Chimie ParisTech graduate school where he founded the Crystal and Quantum State Dynamics Group. The team develops doped various types of crystals for optical quantum technologies. He coordinated the FET-Open project NanOQTech which won him a Stars of Europe award in 2020 and obtained in 2021 an European Union ERC Advanced Grant to develop new hybrid materials for quantum photonics. He received in 2022 the CNRS Silver Medal for outstanding research work and the Philippe A. Guye Prize of the French Academy of Sciences in 2024.

Exploring excited-state behavior in lanthanide-molecule nano hybrids

San-Yang Han

Tsinghua University

The excited-state energy transfer process is crucial for determining key functionalities of lanthanide-molecule hybrid systems, including luminescence, charge carrier transport, and catalytic activity. However, due to the complexity of lanthanide energy level structures, significant differences in excited-state dynamics between components, and uncertainties in nanointerface structures, the mechanism of interfacial energy transfer in such systems remains unclear. Achieving highly efficient energy transfer and strong electronic coupling has become a critical challenge. To address this issue, this presentation systematically introduces our research progress in regulating excited states in lanthanide-based systems. We have successfully developed a novel class of lanthanide-molecule hybrid systems with exceptional performance. The report will focus on fundamental mechanistic insights, including the dynamics of interfacial energy transfer pathways and elucidation of electronic coupling mechanisms. This work not only provides new perspectives and a theoretical foundation for understanding and controlling lanthanide-molecule hybrid systems, but also demonstrates their broad application potential in optoelectronic devices, catalytic conversion, bio-imaging, and other fields.

Short Biography

San-Yang Han

San-Yang Han is currently an associate professor at the Tsinghua University Shenzhen International Graduate School, Tsinghua University. He received his Ph.D. in Chemistry from the National University of Singapore in 2014, and subsequently conducted postdoctoral research at the Cavendish Laboratory, University of Cambridge, UK. He has been recognized as a Marie Skłodowska-Curie Fellow, a National High-Level Young Talent, and a Distinguished Appointee under the "Pengcheng Peacock Plan." Currently, his research focuses on the chemistry and photophysics of lanthanide luminescent materials, spanning multiple disciplines such as chemistry, physics, materials science, interface spectroscopy, and biology. In recent years, he has published over 70 scientific papers in prestigious international journals, including Nature, Nature Photonics, Nature Communications, Angewandte Chemie, Advanced Materials and so on. His research achievements were selected as one of the "Top Ten Rare Earth Science and Technology News in China in 2017" and received a "Nomination Award for China's Top 10 Optical Advances in 2021."

Rare Earth Photophysics

Bin Dong

Dalian Minzu University

Rare Earth ions 4f Electron Upconversion exhibits advantages such as abundant infrared transitions, broad spectral range, and high resistance, offering irreplaceable advantages in infrared detection, information encryption, and other fields. As a result, it has been widely applied in areas including quantum storage, bioimaging, and information encryption. However, due to the fact that rare earth upconversion luminescence originates from ionic transitions and is subject to forbidden transition effects, rare earth ions suffer from long luminescence lifetimes, limited excitation ranges, and low quantum yields, which severely restrict their practical applications. To address these challenges, we focus on the development, manipulation, and application of rare earth upconversion luminescent materials based on 4f electrons. We have developed novel high-efficiency rare earth upconversion luminescent materials based on sulfides and oxides, proposed a cascade pumping upconversion luminescence approach, achieved an improvement in upconversion luminescence intensity by three to four orders of magnitude, successfully extended the excitation wavelength to 2100 nm, and developed novel upconversion-based encryption and gas sensor devices.

Short Biography

Bin Dong

Dr. Bin Dong is currently a Changjiang Scholar Distinguished Professor and a Leading Talent of the National "Ten Thousand Talents" Program at Dalian Minzu University. His research focuses on the optical physical properties of rare-earth luminescent materials and their applications. As a corresponding and first author, he has published over 150 peer-reviewed articles in high-impact journals, including Nature Communications, Science Advances, Advanced Materials, Light: Science & Applications, and others. His work has garnered over 13,000 citations.

Quantum Teleportation from Telecom Photons to Erbium-Ion Ensembles

Xiao-Song Ma

Nanjing University

To realize a quantum internet, the distribution of quantum states via quantum teleportation with quantum memories is a key ingredient. Being compatible with existing fiber networks, entangled photons and quantum memories at telecom wavelength are of central interest for such a scalable quantum network. Here, we demonstrate quantum teleportation from a telecom-wavelength photonic qubit to a solid-state quantum memory based on erbium-ion ensembles, which have a native optical transition at 1.5 μm telecom C band. To accomplish this, we use chip-scale silicon nitride microresonators to generate entangled photons with narrow linewidth, compatible with the quantum memory. We confirm the quality of the quantum teleportation procedure using quantum state and process tomography techniques, in which both the quantum state and process fidelities exceeds the classical limit. These results pave the way for the realization of scalable quantum networks based on solid-state devices.

Short Biography

Xiao-Song Ma

Professor Xiao-Song Ma joined School of Physics at Nanjing University in 2015. He obtained his B.S. from Nanjing University in 2003, M.S. from Leiden University in 2005 and Ph.D in Physics at University of Vienna in 2010 (supervised by Prof. A. Zeilinger, 2022 Nobel Laureate in Physics). He was a postdoc fellow in the Institute of Quantum Optics and Quantum Information in Vienna from 2010 to 2012, and a Marie Curie fellow in Yale University from 2012 to 2015. Prof. Ma's research area covers long-distance quantum communication, experimental investigations on the foundation of quantum physics and integrated photonics for quantum-enhanced technology.

XingHan 2.0: A Metropolitan-scale Multiplexed Quantum Repeater with Bell Non-locality

Zong-Quan Zhou

University of Science and Technology of China

Here I present a multiplexed quantum repeater protocol based on time measurements (MQR-TM), which combines the high heralding rate of single-photon interference schemes with the phase robustness of two-photon interference approaches. Using this protocol, we have realized a three-node quantum repeater network, XingHan 2.0, deployed in Hefei. The system establishes heralded entanglement between two Eu:YSO crystal memories separated by 14.5 km and yields a violation of the CHSH-Bell inequality by 3.7 standard deviations [arXiv:2508.17940]. I will further discuss our recent proposal for global-scale quantum networking using a novel backbone channel based on a chain of stratospheric balloons [PRA 113, 022614 (2026)]. Simulation results indicate that global-scale entanglement distribution can be achieved with state-of-the-art quantum memories based on Eu:YSO [Nat. Photon. 2026; arXiv:2511.12537] and mature photon sources based on SPDC.

Short Biography

Zong-Quan Zhou

Zong-Quan Zhou is a professor at the University of Science and Technology of China, where he leads the Group of Solid-State Quantum Memories. His research focuses on quantum repeaters and transportable quantum memories based on rare-earth-ion-doped crystals. His key contributions include the proposal of the “noiseless photon echo” quantum memory protocol and the experimental demonstration of long-lived photonic quantum memories and multiplexed quantum repeaters. His representative achievements have been recognized as one of “China's Top 10 News Stories of Scientific and Technological Progress” and one of the “Top 10 Scientific and Technological Advancements in Chinese Universities.”

A thermal-noise-resilient microwave quantum network up to 4 K

You-Peng Zhong

Southern University of Science and Technology

Quantum communication at microwave frequencies is of use in the development of scalable quantum networks. However, such networks are fundamentally constrained by the susceptibility of microwave photons to thermal noise. Here we report a thermal-noise-resilient microwave quantum network with coherent coupling between two superconducting qubits through a 4-K-thermalized niobium–titanium transmission line. By overcoupling the communication channel to a cold load at 10 mK, we suppress the effective thermal occupancy of the channel to 0.06 photons through radiative cooling—a reduction that is 2 orders of magnitude below ambient thermal noise. We then decouple the cold load and rapidly transfer microwave quantum states through the channel while it rethermalizes. With this approach, we achieve a 58.5% process fidelity for quantum state transfer and a 52.3% Bell entanglement fidelity without correcting for readout errors, both exceeding the classical communication threshold of 1/2. We also develop a set-up with improved channel coherence at 1 K and use this to achieve a Bell entanglement fidelity of 93.6%. As a benchmark, we demonstrate that Bell’s inequality is unambiguously violated with this remote entanglement, without correcting for readout errors.

Short Biography

You-Peng Zhong

You-Peng Zhong earned his bachelor's degree from Zhejiang University in 2013 and his Ph.D. from the University of Chicago in 2019, followed by over a year of postdoctoral research at the same institution. From 2020 to 2025, he worked at the Southern University of Science and Technology before joining the Shenzhen International Quantum Academy for a year. In 2026 he became an associate professor at the Southern University of Science and Technology. His primary research focuses on experimental studies in superconducting quantum computing, with over 50 SCI publications, including first/corresponding-author papers in international journals such as Nature, Nature Electronics, and Nature Physics. His notable achievements include the cross-chip transmission of multi-qubit maximally entangled states (GHZ states) and low-loss quantum interconnects. In 2021, he was selected for the National Overseas Young High-Level Talent program, and in 2023 he was named to the MIT Technology Review's "35 Innovators Under 35" Asia Pacific list.

On-Chip Optical Memory Enabled by Bound States in the Continuum – A Silicon-Erbium Hybrid Platform

Yu-Hui Chen

Beijing Institute of Technology

Storing and retrieving photonic qubits are key functionalities for future optical quantum networks, and integrating scalable optical memory units is crucial as these networks expand. Erbium-doped crystals are a promising material platform due to their long coherence times and compatibility with telecom wavelengths. However, traditional quantum memory designs combining silicon-based photonic chips with erbium-doped crystals face challenges: the high refractive index of silicon confines the optical field, leading to weak light-matter interaction and decoherence of erbium ions near interfaces. Consequently, existing integrated quantum memories lag far behind bulk crystal demonstrations in many key performance metrics.

Here, we present an efficient silicon-chip platform utilizing a designed bound state in the continuum (BIC) within a silicon-erbium hybrid system to overcome these limitations. Compared to conventional silicon waveguide hybrid structures, our BIC platform achieves an order-of-magnitude enhancement in light absorption alongside a low propagation loss of 0.5 ± 0.5 decibels per centimeter. Moreover, we demonstrated the storage of photon echo signals at telecom wavelengths. The measured coherence time of 2.6 ± 0.6 microseconds at zero magnetic field closely matches that of bulk crystals. This BIC-based platform, compatible with standard silicon manufacturing, provides a foundational and promising pathway toward practical, scalable quantum memory chips for optical quantum networks.

Short Biography

Yu-Hui Chen

Yu-Hui Chen earned his Ph.D. in Physics from the Institute of Physics, Chinese Academy of Sciences in 2013. He then worked as a postdoctoral fellow in Jevon Londell's Quantum Optics Group at the University of Otago in New Zealand and joined Beijing Institute of Technology in 2018. Dr. Chen's research interests lie at the intersection of quantum optics and nanophotonics. He has developed cryogenic optical-chip testing systems that have been used in the study of rare earth doped crystals.

Quantum state engineering of nuclear spins in solid-state systems based on the central spin model

Heng Shen

Shanxi University

In the central spin model, a single spin interacts coherently with a bath of surrounding spins. As a key model in nuclear magnetic resonance and solid-state physics, it enables the engineering of collective states and the creation of multi-qubit registers. GaAs quantum dots serve as a model platform for the central spin system, featuring an electron qubit coupled to multiple nuclear spin ensembles. Building upon this platform, I will discuss our recent progress on dissipative phase transitions and reservoir-engineered nuclear spin squeezing.

Short Biography

Heng Shen

Heng Shen is currently a full professor at Shanxi University. He received his Ph.D. in quantum physics from the Niels Bohr Institute, Copenhagen University in 2015, and subsequently conducted postdoctoral research at IQOQI, Innsbruck and University of Oxford. He has been recognized as a Newton international Fellow. His research focuses on quantum metrology and quantum computation with spin systems, such as trapped ions, Rydberg atom array, NV center and others. In recent years, he has published dozens of scientific papers in prestigious international journals, including Nature, Nature Physics, Nature Photonics, Physical Review Letters and so on.

Rare-earth Quantum Information: Vision, Status and Outlook

Li-Gang Wang

Peking University

Quantum information is a key frontier of future information technology and plays a strategic role in areas such as quantum communication, quantum computing, and quantum precision measurement. Owing to their unique 4f electronic configuration, rare-earth elements can preserve atom-like energy level structures in solids, featuring long coherence times, rich optical transitions, and natural compatibility with optical communication wavelengths. These properties make rare-earth materials an important platform for quantum light sources, quantum memories, and quantum interfaces. In recent years, rapid progress has been made in rare-earth quantum information, including rare-earth quantum light sources, rare-earth crystal quantum memories, and rare-earth cold-atom systems, forming an emerging interdisciplinary field at the intersection of materials science, physics, and information science.

In this talk, we will introduce the current status and future perspectives of rare-earth quantum information, together with our recent progress in single-photon detection and rare-earth optical systems. We have been developing single-photon detection technologies based on superconducting nanowire single-photon detectors (SNSPDs), while also initiating research on rare-earth quantum light sources and exploring novel nonlinear optical processes such as photon avalanche in rare-earth systems. Through interdisciplinary collaboration across materials science, physics, and information science, we aim to promote the development of the dual national strategic direction of “rare-earth + quantum information.”

Short Biography

Li-Gang Wang is a Researcher/Assistant Professor, Principal Investigator, and PhD Supervisor at the School of Advanced Materials, Shenzhen Graduate School, Peking University. He is a Newton International Fellow of the Royal Society (UK) and a recipient of the National Overseas Young Talents Program. He has published multiple research papers in prestigious journals such as *Science* and *Science Advances* as the first or corresponding author. His work was selected as one of the "Top 10 Scientific Advances in China" by the Ministry of Science and Technology in 2019 and was included in the 2020 National College Entrance Examination (Gaokao) Science Paper II. In 2019, he was awarded the Royal Society Newton International Fellowship. He has conducted extensive research at Peking University, the Cavendish Laboratory at the University of Cambridge in UK, and the Royal Institute of Technology (KTH) in Sweden. Currently, his research group focuses on single-photon and optoelectronic materials, chips, and devices.

Gravitational time dilation in quantum clock interferometry with entangled quantum memories

Mustafa Gündoğan

Humboldt-Universität zu Berlin

Quantum physics allows a system to be prepared in a spatial superposition, whereas general relativity predicts that time ticks at different rates in different gravitational potentials. Combining the two leads to an interesting regime in which a single clock can be delocalized between two heights and evolve coherently both “fast” and “slow”.

In this talk I describe a photonic quantum clock interferometry scheme that makes this regime experimentally accessible by using entangled quantum memories. The clock is encoded in two optical frequency bins, with the clock frequency given by their difference frequency. These excitations are then stored in vertically separated quantum memories for a controllable storage time. Gravitational time dilation then imprints a relative proper-time phase during storage, which is converted upon readout into a measurable collapse-and-revival signature in Hong-Ou-Mandel interference, providing a witness of proper-time induced entanglement between internal and external degrees of freedom [1]. I also discuss how multiphoton frequency entanglement amplifies the proper-time phase, reducing the required height or storage time [2], and I outline realistic parameter regimes with existing atomic and solid-state memory platforms. Such an experiment would therefore provide a direct observation of gravity acting on genuinely quantum systems, and of the entanglement dynamics driven by gravitational time dilation.

References:

- [1] R. Barzel, M. Gündoğan, M. Krutzik, D. Rätzel, and C. Lämmerzahl, *Quantum* 8, 1273 (2024)
- [2] M. Gündoğan, R. Barzel, and D. Rätzel, arXiv:2601.02470 (2026)

Short Biography

Mustafa Gündoğan

Mustafa Gündoğan is a team leader at Humboldt University of Berlin, where he heads the Quantum Memory Team within the Integrated Quantum Sensors group. He was recently awarded an Independent Researcher Grant (from 2026) by the Einstein Foundation Berlin, having previously held a Marie Skłodowska-Curie Fellowship (2020–2023) at the same institution. His current research focuses on quantum memories based on warm and cold atomic gases for quantum networking, satellite-enabled links, and fundamental-physics applications. Before moving to Berlin, he was a Research Associate (2015–2019) at the University of Cambridge, working on colour centres in diamond and single-spin control in the group of Mete Atatüre. He completed his PhD in 2015 at ICFO under the supervision of Hugues de Riedmatten, specialising in rare-earth ion doped quantum memories. He also serves on the editorial board of Royal Society Open Science journal.

Probing local charge networks in a nano-transistor with a single erbium ion

Chun-Ming Yin

University of Science and Technology of China

Understanding local charge environments is critical for solid-state quantum devices, where microscopic charge fluctuations strongly influence electrical and optical properties. Here, we transform the optical response of an Er ion into an active probe of local charge configurations by resolving its spectrum into discrete, countable trap ionization events. Distinct charge states are identified, and each trap is found to induce a characteristic Stark shift, providing a unique spectroscopic fingerprint. Leveraging these observations, we develop a multi-constraint geometric inversion framework that reconstructs the spatial configuration of an Er–trap network by combining independent physical constraints, including gate-voltage shifts, trap-resolved Stark responses, and ionization statistics. Rather than yielding a single deterministic position, the method progressively restricts the allowed geometric configuration, capturing both Er–trap distances and trap–trap correlations. This work establishes a general strategy for mapping microscopic charge configurations in quantum devices and is broadly applicable to other optically active centers and complex solid-state systems.

Short Biography

Chun-Ming Yin

Chun-Ming Yin is a full professor at the University of Science and Technology of China. His research interests include silicon quantum computing, single rare-earth ions and precision measurement.

The Paradigm Shift in Electrochemical Simulation: A Spin Episode under Non-Equilibrium

Zhao-Ming Xia

Ganjiang Innovation Academy, Chinese Academy of Sciences

Understanding spin-dependent processes in electrocatalysis requires moving beyond equilibrium assumptions to describe the dynamic behavior under operating conditions. This work introduces a non-equilibrium, non-periodic grand canonical framework that integrates density functional theory with reaction network analysis to simulate the oxygen evolution reaction (OER) on a Ce single-atom catalyst. By constructing a comprehensive network of 143 intermediates across varying charges and spin multiplicities, we directly compute steady-state turnover frequencies, intermediate coverages, and reaction fluxes. Our simulations reveal a spontaneous spin symmetry breaking under operational bias (1.4 V vs. RHE, pH 14), where the coverage ratio of spin antiparallel state to spin parallel state of O₂ intermediates on Ce (III) exceeds 20:1, starkly contrasting the 1:1 ratio predicted by equilibrium thermodynamics. This emergent spin polarization is driven by kinetic coupling within the reaction network, where the antiferromagnetic state exhibits stronger integration with the dominant low-spin pathway. Sensitivity analysis identifies key poisoning species and rate-determining steps, providing direct strategies for catalyst optimization. This work establishes a general methodology for probing non-equilibrium spin effects in electrocatalysis.

Short Biography

Zhao-Ming Xia

Zhao-Ming Xia currently serves as an Associate Professor at the Ganjiang Innovation Academy, Chinese Academy of Sciences. He earned his Bachelor's, Master's, and Ph.D. degrees from Xi'an Jiaotong University. Following that, he conducted postdoctoral research at Tsinghua University under the supervision of Academician Jun Li. In 2024, he joined the Ganjiang Innovation Academy, Chinese Academy of Sciences. He is engaged in theoretical research and method development in rare-earth electrochemistry and magnetism, having developed the constant-potential electrochemical simulation method and the supported cluster dynamics evolution theory.

Design of Rare-Earth Complexes for Molecular Quantum Functional Materials

You-Song Ding

Ganjiang Innovation Academy, Chinese Academy of Sciences

As functional materials, molecular complexes can effectively integrate the unique physical properties of metal ions with structurally designable organic ligands. Featuring precisely controllable structures and good film-forming processability, they can achieve performance superior to that of conventional pure inorganic or organic materials, thereby demonstrating promising application prospects in advanced functional materials. For example, high-performance novel functional materials such as single-molecule magnets, qubits, and atomic clocks can be rationally constructed via delicate ligand design. Our research centers on the modulation of physical properties in rare-earth complexes via rational control of coordination environments. We have established a general synthetic protocol for tellurium-containing rare-earth complexes, identified rare-earth-based molecular magnetic semiconductors, and unraveled the mechanism by which chalcogen elements govern the magnetic behavior of single-molecule magnets. Moving forward, we will continue to explore rare-earth chalcogenido complexes toward the development of advanced molecular quantum functional materials.

Short Biography

You-Song Ding

You-Song Ding is currently a Young Professor at the Ganjiang Innovation Academy, Chinese Academy of Sciences. His research focuses on the synthesis and physical property investigations of rare-earth metal complexes. As a corresponding (co-corresponding) or first (co-first) author, he has published 30 peer-reviewed articles in high-impact chemistry journals, including *Nat. Synth.*, *Angew. Chem. Int. Ed.*, and *Nat. Commun.* His work has garnered more than 3000 citations, yielding an h-index of 24.

Broadband light-matter interface at 1.5 μm

Qiang Zhou

University of Electronic Science and Technology of China

Light-matter interface at 1.5 μm is an elementary building block for developing quantum networks compatible with fiber communication infrastructures. Towards a scalable quantum network, it requires to develop integrated light-matter interface with broadband and multiplexing capacities. Here we report the progress of fiber-pigtailed broadband integrated light-matter interface at on a laser-written $\text{Er}^{3+}:\text{LiNbO}_3$ waveguide chip. The device allows a quantum storage of up to 330 temporal modes of heralded single photon via a 4-GHz-wide atomic frequency comb. It functions as a light-matter interface for spectrally multiplexed storage of quantum entangled photons via five 4-GHz-wide atomic-frequency-combs with a channel spacing of 15 GHz. Signal photons from time-bin entangled photon pairs at telecom band are sent into the on-chip memory to store and recall. The entanglement-preserving nature of our quantum memory is assessed with an input/output fidelity of $>92\%$ for all the five spectral channels. Our memory system with all-fiber addressing is performed using telecom-band on-chip devices.

Short Biography

Qiang Zhou

Qiang Zhou received his Ph.D. degree in electronic science and technology from Tsinghua University, Beijing, China, in 2011. From 2014 to 2017, he was a postdoctoral fellow with the Department of Physics and Astronomy, Institute for Quantum Science and Technology, University of Calgary, Calgary, AB, Canada. He is currently a full professor with UESTC. His current research interests include quantum information technologies, quantum Internets, quantum computation, quantum photonics, communication systems, quantum optics, quantum enhanced fiber sensing, and nano-photonics.

Spin properties of single Ce ions in LuAG crystal

Kang-Wei Xia

University of Science and Technology of China

Rare-earth ions in solid-state hosts have emerged as promising platforms for quantum information processing due to their unique optical and spin properties. In this work, we investigate the spin dynamics of individual cerium (Ce^{3+}) ions embedded in a lutetium aluminum garnet (LuAG) crystal at the single-ion level. Using optically detected magnetic resonance techniques, we characterize the spin coherence under varying magnetic field strengths. We demonstrate that the application of a high external magnetic field leads to a dramatic enhancement of spin coherence, extending the coherence time by nearly two orders of magnitude compared to the low-field regime. Our results reveal a clear dependence of coherence properties on the magnetic field orientation and magnitude, providing insight into the underlying decoherence channels. These findings establish single Ce^{3+} ions in LuAG as a viable platform for robust quantum spin control and highlight the critical role of high magnetic fields in optimizing coherence. This work paves the way toward scalable rare-earth-based quantum technologies and hybrid quantum systems.

Short Biography

Kang-Wei Xia

Kang-Wei Xia is a professor in USTC. He obtained PhD in Uni-Stuttgart 2016. His research focuses on single rare earth spectroscopy and optical information storage.

Cold-atom based quantum networks: from many to single, then to many again

Yong Yu

University of Science and Technology of China
Hefei National Laboratory

Cold atoms represent one of the earliest and most enduring platforms for quantum information processing, remaining at the forefront of the field. Owing to their intrinsic homogeneous optical interface and relatively long coherence times, ensembles of cold atoms were among the first physical systems to be experimentally developed for quantum networking. As the platform has advanced, the limitations of the initial protocols have become more apparent, driving a transition of the system towards experiments with individual atoms. In this talk, I will review this evolution and provide an outlook on the future development of the platform.

Short Biography

Yong Yu

Yong Yu is a professor at the USTC. His research interest includes cold atoms, rare-earth ions, as well as quantum optomechanics. Currently, he leads a group focusing on quantum networking and advanced quantum information processing using individual neutral atoms.

Heterogeneous entanglement between a trapped ion and a solid-state quantum memory

Tian-Xiang Zhu

University of Science and Technology of China

Hybrid quantum networks offer a promising architecture for scalable quantum information processing and a future quantum internet, as they can combine the complementary strengths of disparate physical platforms. While single-atom systems provide deterministic quantum logic gates, atomic ensembles enable large-capacity quantum storage. However, generating entanglement between such heterogeneous systems has remained an open challenge, primarily due to fundamental spectral mismatches and system complexity. Here, we demonstrate a hybrid quantum network that entangles a single trapped 171Yb^+ ion and a quantum memory based on $153\text{Eu}^{3+}:\text{Y}_2\text{SiO}_5$ crystal over a 75-m separation. Using polarization-maintaining quantum frequency conversion, we map spin-photon entanglement onto a hybrid entanglement between a single spin qubit and a collective excitation of the quantum memory. The resulting entangled state achieves a fidelity of $(89.21 \pm 2.23)\%$ and violates the CHSH-Bell inequality by 6 standard deviations $S=2.328 \pm 0.055$, confirming nonlocality between two heterogeneous nodes. This work establishes entanglement between a quantum processing module with a multiplexed quantum memory node, representing a key step toward a scalable, multifunctional quantum internet.

References:

- [1] Kimble, H. J. The quantum internet. *Nature* **453**, 1023–1030 (2008).
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Short Biography

Tian-Xiang Zhu

Tian-Xiang Zhu currently serves as an associate researcher at the University of Science and Technology of China (USTC). He obtained his B.S. degree from Inner Mongolia University in 2018 and earned his Ph.D. from the USTC in 2023. Following his doctoral studies, he conducted postdoctoral research at USTC and was appointed as a specially appointed associate researcher in 2025. His research focuses on quantum information, with a long-term commitment to the study of quantum memory and quantum networks based on rare-earth-ion-doped crystals.

Storage of telecom-band time-bin qubits in thin-film lithium niobate

Tian-Shu Yang

Shanxi University

Lithium niobate (LiNbO_3) is a leading platform for integrated quantum photonics, owing to its wide transparency window, large nonlinear coefficient, strong electro-optic effect, and excellent acousto-optic properties. Here, we report the realization of an on-chip optical quantum memory in thin-film lithium niobate (TFLN) via erbium-ion doping, leveraging their coherent optical transitions. The memory operates at the telecommunications wavelength of 1532 nm and is implemented using the atomic frequency comb protocol. We achieve a storage efficiency of 1.95% at a storage time of 400 ns. Using time-bin encoded qubits, we measure a storage fidelity of up to 97%, exceeding the classical limit and confirming the quantum nature of the device. To our knowledge, this constitutes the first demonstration of an on-chip quantum memory for telecom-band time-bin qubits in TFLN, representing a key step toward fully integrated quantum registers and quantum repeater architectures for scalable quantum information processing.

Short Biography

Tian-Shu Yang

Tian-Shu Yang is an Associate Professor at Shanxi University. He received his B.S. and Ph.D. degrees from the University of Science and Technology of China (USTC) in 2015 and 2020, respectively. He subsequently conducted postdoctoral research at USTC before joining Shanxi University in 2022. His research focuses on experimental studies of quantum memory based on rare-earth-ion-doped thin-film lithium niobate.

Optically Detected and Modulated Magnetic Resonance of Rare-Earth Ions

Ye-Xin Wang

Quantum Science Center of Guangdong-Hong Kong-Macao Greater Bay Area

Spin-optical interface based on circularly polarized light to directly inject angular momentum into spin carriers by selective excitation provides a generalizable route for spin polarization and readout. However, it is yet underexplored among chemically synthesized systems. In this work, monodispersed CaS:Ce(III) nanocrystals were used to demonstrate the feasibility of this mechanism on a broader material basis. CaS host possesses high symmetry, low magnetic noise, redshifted photoluminescence spectra and openness to further functionalization. The mechanism of the spin selectivity is analytically derived and numerically verified according to the low-temperature photoluminescence spectra. We built a cryogenic confocal optically-detected magnetic resonance (ODMR) spectrometer to realize the optical spin polarization and conduct pulsed ODMR experiments, with a detection limit of 10^5 spins. At 2.9 K and 350 G, the spin polarization exceeded 12%. Spin-lattice relaxation time $T_1=0.65(2)$ ms, spin coherence time $T_2=1.2(3)$ μ s and dephasing time $T_2^*=45(7)$ ns were derived. To the best of our knowledge, this is the first realization of ODMR on chemically synthesized nanocrystals.

In addition, we developed a light modulation method based on the continuous-wave mode of commercial electron spin resonance spectrometer. Capable of detecting spin transitions coupled to optical processes, this technique can be used for quick and sensitive characterizations of the spin-optical coupling in larger ensembles and their kinetic properties.

Short Biography

Ye-Xin Wang

Ye-Xin Wang is an Assistant Researcher at Quantum Science Center of Guangdong-Hong Kong-Macao Greater Bay Area. He received his B.S. and Ph.D. degrees from Peking University in 2014 and 2021 respectively, and subsequently conducted postdoctoral research at South China University of Technology (SCUT) before joining the current institution in 2023. His research focuses on the optically-detected magnetic resonance of molecules and nanomaterials, and the application of spin-optical interface.

Toward Telecom-Band Quantum Nodes Using Rare-Earth Stoichiometric Crystals

Fu-Dong Wang

Shenzhen International quantum Academy

Doping erbium ions into europium-based hosts provides a promising platform for quantum repeater nodes, combining europium's exceptional coherence for long-term quantum storage with erbium's microwave compatibility and direct telecom-band optical transitions. Here we investigate erbium-doped $\text{EuCl}_3 \cdot 6\text{H}_2\text{O}$ stoichiometric crystals as a candidate system for such hybrid quantum nodes. Er^{3+} doping shifts the optical transition frequencies of nearby Eu^{3+} ions, producing well-resolved satellite lines in the inhomogeneous absorption profile. By probing Er^{3+} - Eu^{3+} interactions under varying temperature and magnetic-field conditions, we measure coupling strengths ranging from tens to hundreds of kilohertz, depending on field orientation, magnitude, and Eu^{3+} lattice position. At 60 mK and a magnetic field of 0.1 T, we observe a strong frozen-core effect from Er^{3+} spins that significantly extends the Eu^{3+} optical coherence time and enables hour-long hyperfine-state lifetimes. These results highlight the potential of dual-species rare-earth crystals for photonic quantum technologies and quantum repeater architectures.

Short Biography

Fu-Dong Wang

Fu-Dong Wang earned his Ph.D. in Physics from the Chinese University of Hong Kong in 2016, followed by postdoctoral research at University of Toronto. Before moving to Shenzhen International Quantum Academy in 2025, he worked at Shenzhen Institute for Quantum Science and Engineering. His research interests lie at the quantum optics based on rear-earth ions doped crystals.

Posters

Coherence Properties of Rare-Earth Spins in Micrometer-Thin Films

Zi-Hua Chai

University of Science and Technology of China

Rare-earth ions in bulk crystals are excellent solid-state quantum systems in quantum information science, owing to the exceptional optical and spin coherence properties. However, the weak fluorescence of single rare-earth ions presents a significant challenge for scalability, necessitating the integration into micro-cavities. Thin films serve as a promising material platform for the integration, yet the fabrication without compromising the properties of the materials and rare-earth ions remains challenging. In this work, we fabricate micrometer-thin yttrium aluminum garnet (YAG) films from bulk crystals using ion implantation techniques. The resulting films preserve the single-crystalline structure of the original bulk crystal. Notably, the embedded rare-earth ions are photo-stable and exhibit bulk-like spin coherence properties. Our results demonstrate the compatibility of bulk-like spin properties with the thin-film fabrication technique, facilitating the efficient integration of rare-earth ions into on-chip photonic devices and advancing the applications of rare-earth ions systems in quantum technologies..

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Short Biography

Zi-Hua Chai

Zi-Hua Chai received the B.S. (2017) and Ph.D. (2023) from the University of Science and Technology of China, respectively. He specializes on quantum manipulation and simulation based on single rare-earth ions and NV centers in diamond. He has authored multiple publications in journals such as *Science Advances*, *Physical Review Letters* and *ACS Photonics*.

Establishing Stoichiometric Rare-earth Crystals for Long-lived Quantum Memories

Mucheng Guo^{1,2,*}, Zhehao Xu^{1,2,*}, Weiye Sun^{1,2}, Fudong Wang^{2,†}, Shuping Liu^{2,†} and Manjin Zhong^{2,†}

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Quantum networks distribute quantum states between remote nodes, enabling secure communication, distributed quantum computing, precision sensing, and fundamental tests of quantum physics. A key resource for such networks is the quantum memory, which is required to store and retrieve quantum states on demand. Nuclear spins in rare-earth-ion-doped crystals are promising platforms for this task, offering long coherence together with direct optical access. However, achieving long coherence times has typically relied on diluting the ions to suppress ion-ion interactions, which severely reduces optical depth and therefore limits memory efficiency [1-3]. Stoichiometric rare-earth crystals offer intrinsically high optical depth, yet their spin-coherence properties in such dense spin systems have remained largely unexplored [4-5]. Here we explore the spin dynamics of a stoichiometric $\text{EuCl}_3 \cdot 6\text{H}_2\text{O}$ crystal and demonstrate that it supports ultra-long spin coherence [5]. At 4 K and zero magnetic field we measure a 1.3 ms nuclear spin coherence time, which increases to 372 ms at a zero-first-order-Zeeman(ZEFOZ) point. This work overcomes the trade-off between coherence and light-matter coupling, establishing stoichiometric rare-earth crystals as a compelling platform for efficient, long-lived quantum memories and scalable quantum networks.

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Short Biography

Mucheng Guo

Mucheng Guo received a B.S. degree in Physics from Shanxi University in 2021. In the same year, he joined the research group of Dr. Manjin Zhong at Southern University of Science and Technology (SUSTech) as a master's student, and transitioned to a Ph.D. in 2023. His research interests focus on the application of erbium-ion-doped single crystals and stoichiometric rare-earth crystals in quantum networks, particularly in the context of quantum communication and information processing.

Zhehao Xu

Zhehao Xu graduated in 2019 with a B.S. degree in Applied Physics from China Jiliang University and has been pursuing a master's degree in Quantum Science and Engineering at Southern University of Science and Technology (SUSTech) since 2023. His research mainly focuses on coherence characterization and quantum memory in stoichiometric single crystals.

打破进口依赖：国产高品质掺铈硅酸钇晶体研制成功

梁澎军

合肥国家实验室

基于掺铈硅酸钇晶体的可移动量子存储器是实现长距离量子通信的可行方案，其需要达到小时量级的存储寿命。同位素富集的掺铈硅酸钇晶体是该应用的重要候选材料，但其光学存储效率和自旋存储寿命受限于较宽的非均匀线宽。此前，中国量子存储应用所需的高质量掺铈硅酸钇晶体主要从美国和法国进口，但两国现已对中国实施出口禁运。在本工作中，我们成功生长出了与进口晶体质量相当的掺铈硅酸钇晶体，并已在多项实验中成功应用[1-3]。

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Efficient integrated quantum memory using waveguide cavity

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Scalable implementation of quantum networks and photonic processors demand integrated photonic quantum memories with high efficiency, yet current integrated systems have been limited to storage efficiencies below 27.8% [1]. Cavity-enhanced quantum memory is a universal method to improve memory efficiency, especially with the sample with low absorption like rare-earth ion (REI) doped crystals.

However, the former demonstrations of efficient cavity-enhanced quantum memory are all in bulky systems. Furthermore, their efficiencies are limited by cavity linewidth and intra-cavity loss [2-3]. Here, we demonstrate highly efficient integrated quantum memories based on REI-doped crystals coupled with waveguide-based cavities (WGC) fabricated using femtosecond lasers. After carefully optimization of the fabrication process, we achieve an ultralow propagation loss of 0.1 dB/cm. The narrow cavity linewidth caused by slow light effect is mitigated using an absorption-enhanced spectral hole-burning protocol.

With the improvements above, we achieve an efficiency of 80.3(7)% at the storage time of 1 μ s, and on-demand retrieval at 7 μ s using the Stark-modulated atomic frequency comb protocol. This WGC quantum memory not only breaks the efficiency record of integrated quantum memory, but also is the most efficient quantum memory based on REI-doped crystals.

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A Metropolitan-scale Multiplexed Quantum Repeater with Bell Nonlocality

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Quantum repeaters can overcome the exponential photon loss inherent in optical fibers, enabling the generation of heralded entanglement between remote quantum memories[1]. The ultimate benchmark of this entanglement is Bell nonlocality, the resource that underpins device-independent security[2]. However, previous attempts to demonstrate heralded entanglement between quantum memories separated by metropolitan-scale distances have failed to achieve certification of Bell nonlocality due to the insufficient quality of entanglement produced by single-photon interference schemes.

1. Here, we report the successful generation of heralded entanglement between two solid-state quantum memories, which are spatially separated by 14.5 km and temporally multiplexed with 1205 modes[3].

2. Using a two-photon interference scheme, we prepare a Bell state with fidelity $78.6 \pm 2.0\%$. A CHSH-Bell test yields $S=2.22 \pm 0.06$ (>2 by 3.7σ), providing the first unambiguous certification of Bell nonlocality between quantum memories at metropolitan distances[3].

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Efficient integrated quantum memory for light

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Scalable implementation of quantum networks and photonic processors require integrated photonic memories with high efficiency, yet current integrated systems have been limited to storage efficiencies below 27.8%^[1,2]. Here, we demonstrate highly efficient integrated quantum memories based on rare-earth-ion doped crystals coupled with impedance-matched microcavities, realized in a novel architecture: 200- μm -thin membranes of $\text{Eu}^{3+}:\text{Y}_2\text{SiO}_5$ integrated with fiber-based microcavities. Our approach achieves reliable integrated quantum storage with record efficiencies of 75.2(5)% for weak coherent pulses and 69.8(1.6)% for telecom-heralded single photons, alongside the storage of 20 temporal modes with an average efficiency of 51.3(2)%. Moreover, the thin-membrane $\text{Eu}^{3+}:\text{Y}_2\text{SiO}_5$ architecture enables spectrally tunable efficient quantum storage via variable strain, providing a flexible interface for quantum networks. By combining high efficiency, large multimode capacity, and tunability, our devices establish a versatile hardware foundation for scalable quantum repeaters and chip-scale photonic processors.

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Direct generation of telecom-band spin-photon entanglement violating Bell inequality

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Quantum nonlocality, typically revealed through entanglement distribution across quantum networks, is a cornerstone of quantum information science. Long-range distribution of entanglement requires the information carrier, i.e. flying photons, to operate in the minimum-loss telecom C-band of optical fibers. While extensive efforts have been devoted to the direct generation of entanglement between C-band telecom photons and various stationary spins, the verification of quantum nonlocality remains an outstanding challenge. Here, utilizing a dipole transition in rubidium atoms with a wavelength of 1530 nm, we achieve resonant excitation and direct emission of C-band telecom photons from a single atom, generating spin-photon entanglement with a measured Bell state fidelity exceeding 91.4%. We then verify quantum nonlocality by observing a Bell inequality violation of $2.455(77) > 2$ using this high-quality entangled pair. This work demonstrates the first verification of quantum nonlocality in a directly generated spin-photon entanglement in the telecom C-band enabled by the excellent coherence and well-established state manipulation of a single neutral atom, paving the way toward the deployment of an atom-based quantum network capable of scalable quantum computation and long-range quantum communication.

Sub-second Spin and Lifetime-Limited Optical Coherences in $^{171}\text{Yb}^{3+}:\text{CaWO}_4$

Peng-Rui Jiao

Chimie ParisTech - PSL University

Optically addressable solid-state spins have been extensively studied for quantum technologies, offering unique advantages for quantum computing, communication, and sensing. Advancing these applications is generally limited by the availability of materials that simultaneously provide lifetime-limited optical coherence and long spin coherence times. Here, we introduce $^{171}\text{Yb}^{3+}$ ions doped into a CaWO_4 crystal. We perform high-resolution spectroscopy of the excited state and demonstrate all-optical coherent control of the electron–nuclear spin ensemble. We observe narrow inhomogeneous broadening of the optical transitions of 185 MHz and a radiative-lifetime-limited coherence time of up to 0.75 ms. In addition, we measure a spin-transition ensemble linewidth of 5 kHz and an electron–nuclear spin coherence time reaching 0.15 seconds at zero magnetic field between 50 mK and 1 K. These results demonstrate the potential of $^{171}\text{Yb}^{3+}:\text{CaWO}_4$ as a low-noise platform for quantum technologies, including ensemble-based quantum memories, microwave-to-optical transducers, and optically addressable single-ion spin qubits.

酒店会场指引

注册酒店地图



会议报到时间：2026年4月10日，9:00-22:00。

会议报到地点：安徽合肥稻香楼宾馆桂苑。

交通方式：

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