Q 73: Quantum Technologies – Solid State Systems

Time: Friday 11:00–13:00 Location: P 7

Invited Talk Q 73.1 Fri 11:00 P 7

Microwave quantum communication with rare-earth spin ensembles — •Nadezhda Kukharchyk — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, D-85748 Garching, Germany — School of Natural Sciences, Technische Universität München, D-85748 Garching, Germany — Munich Center for Quantum Science and Technology, D-80799 Munich, Germany

Microwave quantum communication, encompassing the development of microwave quantum key distribution (QKD), quantum microwave entanglement distribution, and compatible quantum storage elements, is a highly promising area in the evolution of radio technologies toward 6G wireless networks. In our work, we focus on the development of microwave quantum memories that are compatible with microwave quantum circuits, which play a central role in quantum computing and microwave QKD protocols.

In this talk, I will present our progress in the development of broadband microwave quantum memories based on rare-earth spin ensembles, discuss their envisioned integration with microwave QKD systems, and explore potential applications in next-generation quantum communication networks.

Q 73.2 Fri 11:30 P 7

Some defects in silicon-based material – towards integrated silicon photonics — •Philipp Kellner, Bernd Hähnlein, Kevin Lauer, Christian Möller, Kai Kühnlenz, Mario Bähr, and Thomas Ortlepp — CIS Inst. für Mikrosensorik, Konrad-Zuse-Straße 14, 99099 Erfurt

For years Silicon is known as the standard VIS and NIR sensor material, although an indirect semiconductor. It is still a material of choice for optoelectronics, due to known handling and structuring procedures as well as CMOS-compatibility allowing for highly integrated devices. The given presentation will shed light on defect-based light emitter in indium-doped silicon and gallium implanted silicon-nitride, showing generation methods and photoluminescence spectra. Abbe-limited optical microscopy is going to be used for imaging and photostability will be estimated. These experiments will undertake very first steps towards small light sources on silicon chips and in turn integrated silicon photonics.

Q 73.3 Fri 11:45 P 7

Toward an Efficient Quantum-Photonic Interface for Rare-Earth Ions on a Hybrid LNOI-TiO_2 Platform — •Tobias Feuerbach[1], Georgii Grechko[1], Christopher Ng[1], Roman Kolesov[1], and Jörg Wrachtrup[1,2] — [1]3rd Institute of Physics, University of Stuttgart, Germany — [2]Max Planck Institute of Solid State Research, Stuttgart, Germany

Over the years rare-earth ions (REIs) have gained attention for quantum memory applications due to their telecom wavelength compatibility and exceptional coherence times. Their low photon rates, however, make cavity-enabled Purcell enhancement necessary.

Hybrid-material photonic crystal cavities (PCCs) are a promising approach for photonic integration of REIs, combining the strengths of different materials. We employ a hybrid photonic system that merges lithium niobate on insulator (LNOI), offering electro-optical tunability and scalable fabrication, with TiO_2, a high-index and spin-free host for REIs, enabling scalable, tunable and efficient quantum photonic interfaces at telecom wavelength.

We compare techniques for Er^{3+} integration into rutile TiO_2 waveguides and discuss our hybrid TiO_2/LNOI process, that is based on the fabrication of freestanding TiO_2 structures, Van-der-Waals bonding to x-cut LNOI and subsequent nanofabrication of the combined stack. Specifically, tunable hybrid PCCs made from TiO_2/LNOI are presented. A loaded Q-factor of 42k and a tunability of 0.8 GHz/V is achieved. We use a bifocal microscope for spectral characterization, enabled by a custom freespace-to-chip coupling technique.

Q 73.4 Fri 12:00 P 7

Detecting Bell-Operator Correlations in Superconducting Devices — Ke Wang[1], Weikang Li[2], Shibo Xu[1], Mengyao Hu[3], Jiachen Chen[1], Yaozu Wu[1], Chuanyu Zhang[1], Feitong Jin[1], Xuhao Zhu[1], Yu Gao[1], Ziqi Tan[1], Zhengyi Cui[1], Aosai Zhang[1], Ning Wang[1], Yiren Zou[1], Tingting Li[1], Fanhao Shen[1], Jiarun Zhong[1], Zehang Bao[1], Zitian Zhu[1], Zixuan Song[1], Jinfeng Deng[1], Hang Dong[1], Xu Zhang[1], Pengfei Zhang[1], Wenjie Jiang[1], Zhide Lu[1], Zheng-Zhi Sun[1], Hekang Li[1], Qiujiang Guo[1], Zhen Wang[1], •Patrick Emonts[3,4], Jordi Tura[3], Chao Song[1], Hao Wang[1], and Dong-Ling Deng[2] — [1]Zhejiang University, China — [2]Tsinghua University, China — [3]Leiden Univsersity, The Netherlands — [4]Ulm University, Germany

Quantum nonlocality represents a stronger form of quantum correlation than entanglement and defies Einstein's notion of local realism. It serves as a key resource for applications such as cryptography or certified randomness. Yet, detecting nonlocality in many-body systems remains highly challenging. In this talk, I present the experimental viability of Hamiltonians to certify genuine multipartite Bell-Operator correlations in systems up to 24 qubits on a programmable superconducting processor. As an example, we variationally prepare a low-energy state of a 73-qubit honeycomb model and certify its Bell-Operator correlations by measuring an energy exceeding the classical bound by 48 standard deviations. This establishes a practical route for preparing and certifying multipartite Bell correlations as a stronger benchmark beyond entanglement (Phys. Rev. X 15, 021024, 2025).

Q 73.5 Fri 12:15 P 7

Effect of Heterostrain on the Photophysical Properties of WSe2/MoSe2 Heterobilayers — •Hilal Korkut and Ibrahim Sarpkaya — Bilkent University, UNAM (National Nanotechnology Research Center), Ankara, Turkey

Transition metal dichalcogenides have attracted broad interest due to their exceptional mechanical, electronic, and optical properties1. Owing to their long lifetime, permanent out-of-electric dipole, and high tunability provide an excellent platform for exploring correlated interactions and valley-dependent physics2. In this talk, I will present how heterostrain modifies the low-temperature optical responses of interlayer excitons in WSe2/MoSe2 heterobilayers and demonstrate how strain can be utilized as a means of controlling these properties. References 1.*Wang, G. et al. Colloquium: Excitons in atomically thin transition metal dichalcogenides. Rev. Mod. Phys. 90, 21001 (2018). 2.*Durmuş, M. A., Demiralay, K., Khan, M. M., Atalay, Ş. E. & Sarpkaya, I. Prolonged dephasing time of ensemble of moiré-trapped interlayer excitons in WSe2-MoSe2 heterobilayers. npj 2D Mater. Appl. 2023 71 7, 1*8 (2023).

Q 73.6 Fri 12:30 P 7

Nanophotonic engineering to enhance laser cooling via Erbium ions — •Nilesh Goel, Florian Burger, Andrew Propper, Stephan Rinner, Andreas Gritsch, Kilian Sandholzer, and Andreas Reiserer — Technical University of Munich, TUM School of Natural Sciences, Physics Department and Munich Center for Quantum Science and Technology (MCQST), James-Franck-Str. 1, 85748 Garching, Germany

The cooling of solid-state quantum systems is a key requirement for their coherent operation. Conventional cryocoolers are limited by their large size, power consumption, and added vibrations. Therefore we explore an alternative route: on-chip laser cooling of silicon nanostructures using erbium dopants as local refrigerants. While direct optical refrigeration of semiconductors is challenging, erbium ions embedded in a nanophotonic slow-light waveguide can efficiently pump entropy from the phonon bath into a guided light mode. In a first experiment, we show how this allows for accurate temperature measurement [1]. To enhance the cooling process, we then use slow-light engineering to tailor the local density of states over a broad spectral range. This way we can suppress the unwanted radiative channels [2] to suppress competing decay pathways, thereby improving the cooling efficiencies of the system. We show the current progress towards this goal and outline the next steps toward enhanced laser cooling in solid state systems.

[1] K. Sandholzer et al., Nanophotonics 14, 2005 (2025).
[2] F. Burger et al., arXiv:2511.23301 (2025).

Q 73.7 Fri 12:45 P 7

Optically detected nuclear magnetic resonance of coherent spins in a molecular complex — •Vishnu Unni Chorakkunnath, Evgenij Vasilenko, Preethika Thiraviam, Nicholas Jobbitt, Barbora Brachnakova, Senthil Kuppusamy, Mario Ruben, and

David Hunger — Karlsruher Institut für Technologie, Karlsruhe, Germany

A europium-based molecular complex has recently shown [1] competitive optical coherence time, surpassing those of europium-doped solid-state nanocrystals. Molecular complexes offer the possibility of tailoring ligand fields to improve and control optical and spin properties to realize optically addressable spin qubits. We report the first optically detected nuclear magnetic resonance (ODNMR) in a molecular complex. We observe nuclear Rabi-oscillations and spin coherence times (T2) of ~600*s in a single-crystal sample of the molecular complex at 4.2K. The spin coherence is extended up to 2ms with dynamical decoupling. Furthermore, we report strong nuclear and optical transition frequency correlation [2]. The self-assembly of molecular complexes into high-quality crystals improves optical and spin properties. Such crystals can be integrated into fibre-based microcavities [3] to enhance emission rates by the Purcell effect. These results are important steps towards single Eu3+ ion experiments to realize optically addressable spin qubits.

[1] Serrano et al., Nature, 603, 241-246 (2022)
[2] Vasilenko et al., arXiv:2509.01467 (2025)
[3] Eichhorn et al., Nanophotonics 14, 1817 (2025)