Invited talks

Monday, December 8, 2025

Electron spin ensembles for microwave quantum communication

Nadezhda Kukharchyk, *Walther-Meißner-Institut der BAdW, TUM*

Abstract: 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 recent progress in the development of broadband microwave quantum memories based on spin ensembles, discuss their envisioned integration with microwave QKD systems, and explore potential applications in next-generation quantum communication networks.

Quantum networking resources and applications

Eleni Diamanti, *LIP6, Sorbonne University, CNRS*

Abstract: We discuss the main concepts, critical photonic resources, present efforts and challenges ahead aiming at the deployment of quantum communication networks at various stages of development, with both terrestrial and satellite links, at a national and global scale. We present examples of applications of such networks spanning from ultrasecure communication to advanced cryptographic and communication protocols in distributed architectures.

Optimal Control for Robust Quantum Operations and Multi-Qubit State Engineering in Superconducting Circuits

Stefan Filipp, *Walther-Meißner-Institut der BAdW, TUM*

Abstract: Superconducting qubits have emerged as a promising platform for quantum computing, offering scalability, precise controllability, and strong integration potential. A central requirement for reliable quantum information processing is the ability to generate quantum states in a robust fashion, insensitive to control imperfections and noise. In this work, I present an optimal control scheme that enables gate operations resilient to both amplitude and frequency noise. To efficiently generate entanglement, I further introduce a method for single-step GHZ state creation, which can be naturally extended to the preparation of W-states, providing a versatile framework for multi-qubit state engineering. These results underscore the potential of superconducting qubits as a foundational technology for scalable and fault-tolerant quantum architectures.

Self-concordant Schrödinger operators: spectral gaps and optimization without condition numbers

Simon Apers, *IRIF, Paris Cité University, CNRS*

Abstract: Motivated by convex optimization, we study Schrödinger operators associated with self-concordant barriers over convex domains and prove non-asymptotic lower bounds on the spectral gap for this class of operators. Significantly, we find that the spectral gap does not display any condition-number dependence when the usual Laplacian is replaced by the Laplace–Beltrami operator, which takes the curvature of the barrier into account. As an algorithmic application, we construct a novel

quantum interior point method that applies to arbitrary self-concordant barriers and shows no condition-number dependence. To achieve this we combine techniques from semiclassical analysis, convex optimization, and quantum annealing.

Tuesday, December 9, 2025

Universal non-Gaussian statistics of the order parameter in the superfluid transition

Thomas Chalopin, *LCF, IOGS, Paris-Saclay University, CNRS*

Abstract: Second-order phase transitions describe how a many-body system evolves from an ordered phase, where the order parameter is finite, to a disordered phase, where it vanishes. Near the transition, scale invariance and universality yield algebraic scaling laws for thermodynamic quantities such as the correlation length or the susceptibility, which do not depend on the microscopic details of the model. Moreover, at the transition, the order parameter takes universal non-Gaussian statistics.

In this talk, I will present recent experiments in which we explore the interaction-induced superfluid transition with ultracold lattice bosons and single-atom resolution in momentum space. We measure the statistics of the amplitude of the BEC order parameter and characterise its non-Gaussian behaviour near the transition by exploiting high-order cumulants of the order parameter distribution. We compare datasets with different entropies and observe a universal collapse of the cumulants near the transition. Our experiments enable the measurement of critical exponents compatible with the 3D XY model.

Allemand et al., Observation of universal non-Gaussian statistics of the order parameter across a continuous phase transition, arXiv:2508.21623 (2025)

Probing the spatial distribution of k-vectors in-situ with Bose-Einstein condensate

Saïda Guellati-Khelifa, *LKB, Sorbonne University, CNRS*

Abstract: In this talk, I will present our recent work on the measurement in-situ of the distribution of the wave vectors across a laser beam, using a Bose-Einstein condensate (BEC) as a mobile probe. By displacing the BEC, we measure the photon recoil at various positions using an atom interferometer, allowing us to determine the 2D map of both the local intensity and the dispersion of the wave vectors.

Using a laser beam diffracted by a diaphragm, our method reveals an extra recoil, with an amplitude exceeding the magnitude *hν/c* of the individual plane waves into which the beam can be decomposed. This approach offers a precise way to characterize wavefront distortions and evaluate one of the main systematic biases that limit the accuracy of atom interferometers.

Optically addressable spin systems in diamond and proteins for quantum sensing and imaging

Dominik Bucher, *TUM School of Natural Sciences*

Abstract: Optically addressable spins have attracted significant interest for their potential in quantum sensing technologies. In the first part of this talk, I will present our recent advances using nitrogen-vacancy (NV) centers in diamond chips for nuclear magnetic resonance (NMR) microscopy. NV-doped diamond platforms enable the transduction of local magnetic resonance signals into optical signals, which can be captured over a wide field using a camera. This novel approach eliminates the need for traditional k-space sampling with magnetic field gradients, as used in conventional MRI. I will discuss

the current limitations of this novel microscopy technique and outline prospects for future developments. [1]

In the second part, I will highlight our latest research on optically addressable spins in proteins—specifically flavin-based cryptochrome proteins. Upon excitation, these proteins generate radical pairs that can be detected optically and manipulated through radio wave-controlled spin chemistry. We further show that this optical spin interface is tunable by the protein structure. I will explain how these systems differ from the well-established NV center and discuss their potential as genetically encoded quantum sensors for future applications. [2]

[1] K. D. Briegel et al. Optical Widefield Nuclear Magnetic Resonance Microscopy. Nature Comm, 16, 1281 doi.org/10.1038/s41467-024-55003-5 (2025)

[2] K. Meng et al. Optically detected and radio wave-controlled spin chemistry in cryptochrome, BioRxiv https://doi.org/10.1101/2025.04.16.649006 (2025).

Frank Pollmann, *TUM School of Natural Sciences*, TBA…

Contributed talks

Protecting collective qubits from non-Markovian dephasing

Alexei Ourjoumtsev, *JEIP Collège de France, CNRS*

Abstract: In quantum technologies, qubits encoded as collective atomic or solid-state excitations present important practical advantages, such as strong directional coupling to light. Unfortunately, they are affected by inhomogeneities between the emitters, which make them decay into dark states. In most cases, this process is non-Markovian. Through a simple formalism, we unveil a regime where this decay is suppressed by a combination of driving and non-Markovianity. We experimentally demonstrate this “driving protection” using a Rydberg superatom, making its coherent Rabi oscillations last about 14 times longer than the free lifetime of the collective qubit.

Quantum Communication using single photon emitters in 2D materials

Mostafa Abasifard, *TUM School of Natural Sciences*

Abstract: The global deployment of quantum key distribution (QKD) requires free-space quantum communication via satellite constellations that can operate efficiently and continuously, day and night. Maximizing the secret key rate in these links requires space-qualified, bright, true single-photon sources. We develop and fabricate single-photon sources (SPSs) based on color centers in hexagonal boron nitride, which emit distinct wavelengths for free-space quantum links and are simultaneously compatible with fiber-based quantum networks. We implement QKD protocols to demonstrate the advantages of these SPSs.

Long-range CCPhase gates via radio-frequency-induced Förster resonances

Ivan Ashkarin, *LAC, Université Paris-Saclay, CNRS*

Abstract: Registers of trapped neutral atoms, excited to Rydberg states to induce strong long-distance interactions, are extensively studied for direct applications in quantum computing. Here we present a CCPhase quantum phase gate protocol based on radio-frequency-induced Förster resonant interactions in the array of highly excited ^{87}Rb atoms. The extreme controllability of interactions

provided by rf field application enables high-fidelity and robust gate performance for a wide range of parameters of the atomic system, as well as it significantly facilitates the experimental implementation of the gate protocol. Taking into account finite Rydberg states lifetimes, we achieve.

→ To be continued…