2ND BOS.QT DAY 2024

May 23rd | Magnus Haus | Am Kupfergraben 7 | Berlin

08:30-09:00	**Registration**
09:00-09:05	Welcome Remarks
Morning Session	
09:05-09:40	**Molecules are Qool!:** Organic Molecules for Photonic Quantum Technologies Maja Colautti, European Laboratory of Non-Linear Spectroscopy
09:40-10:15	**Shedding Light on Nuclear Spins: Through the looking glass** Mete Atatüre, University of Cambridge
10:15-10:40	Coffee Break
Session: Academia in Context	
10:40- 11:15	**Academic Detox** Johannes Schöning, University of St. Gallen
11:15- 11:50	**Gender & Diversity in the Cultures of Physics** Martina Erlemann, Freie Universität Berlin
11:50- 12:20	Discussion
12:20- 13:30	Lunch Break
13:30-14:30	Assembly meeting and PhD session
14:30- 15:30	Walk in the historic center of Berlin
Afternoon Session	
15:35- 16:10	**Reliable quantum computational advantages from quantum simulation** Jara Juana Bermejo Vega, University of Granada
16:10- 16:45	**Generation and use of highly entangled photons from GaAs Quantum Dots** Armando Rastelli, Johannes Kepler University (JKU) Linz **[Online Talk]**
16:45-16:55	**Coffee Break**
16:55- 17:30	**Controlling ultracold molecules for quantum science** Giacomo Valtolina, Fritz Haber Institut Berlin
17:30-18:30	Scientific speed dating
18:30- open end	Dinner and goodbye at Nolle Restaurant

MOLECULES ARE QOOL!
ORGANIC MOLECULES FOR PHOTONIC QUANTUM TECHNOLOGIES

MAJA COLAUTTI, EUROPEAN LABORATORY FOR NON-LINEAR SPECTROSCOPY

The generation and manipulation of quantum states of light is required for key applications, such as photonic quantum simulation, linear optical quantum computing, quantum communication protocols, and quantum metrology. In this context, I will present our recent advancements in using single organic molecules as bright and stable sources of coherent single photons in the solid state.
In particular, I will drive you through the challenges we encountered and the solutions we explored while seeking the fundamental goal of going beyond the single-emitter photo-physics towards the coherent interaction of multiple indistinguishable quantum emitters. I will hence discuss the results on two-photon interference (TPI) experiments performed between distinct molecules on the same chip, and our recent insights on how to mitigate the practical limitations on the TPI among distinct emitters via the control of the electrical environment at the nanoscale. The presentation will conclude with some molecule-based proof-of-concept applications in photonic quantum technologies.

SHEDDING LIGHT ON NUCLEAR SPINS: THROUGH THE LOOKING GLASS

METE ATATÜRE, UNIVERSITY OF CAMBRIDGE

Optically active spins in solids are strong candidates for scalable devices towards quantum networks. Semiconductor quantum dots set the state-of-the-art as single-photon sources with high level tuneability, brightness, and indistinguishability. In parallel, their inherently mesoscopic nature leads to a unique realisation of a tripartite interface between light as information carrier, an electron spin as a proxy qubit, and an isolated nuclear spin ensemble. The ability to control these constituents and their mutual interactions create opportunities to realize an optically controllable ensemble of ~50,000 spins. In this talk, I will present a journey from treating the quantum dot nuclei as an uncontrolled noise source limiting spin coherence to the observation of their collective magnon modes and eventually to their capacity as quantum registers, all witnessed via a single electron spin driven by light.

ACADEMIC DETOX

JOHANNES SCHÖNNING, UNIVERSITY OF ST. GALLEN

Academia is plagued by scandals and toxic practices, eroding public trust and undermining the pursuit of knowledge for the common good. Rooted in hypercompetition and limited resources, these issues demand urgent action. In my talk, I will present some "antidotes", such as de-emphasizing metrics, reforming review processes, and advocating for more transparent and clear career pathways to detoxify academia. By challenging power structures and embracing responsible practices, academia can reclaim its commitment to holistic knowledge production and societal advancement.

GENDER & DIVERSITY IN THE CULTURES OF PHYSICS

MARTINA ERLEMANN, FREIE UNIVERSITÄT BERLIN

In the last decades there has been a growing awareness that a scientist's gender can have an impact on a successful career in physics, even though it should have no influence. Moreover, also other categories of diversity and their impact on a career in science get more and more attention. The talk will present research on gender and diversity in physics with a particular focus on studies on the workplace cultures in physics and their impact on young scientists' sense of belonging to the physics community.

RELIABLE QUANTUM COMPUTATIONAL ADVANTAGES FROM QUANTUM SIMULATION

JARA JUANA BERMEJO VEGA, UNIVERSITY OF GRANADA

Demonstrating quantum advantages in near term quantum devices is a notoriously difficult task. Ongoing efforts try to overcome different limitations of quantum devices without fault-tolerance, such as their limited system size or obstacles towards verification of the outcome of the computation. Proposals that exhibit more reliable quantum advantages for classically hard-to-simulate verifiable problems lack, at the same time, practical applicability. In this talk we will review different approaches to demonstrate quantum advantages inspired from many-body quantum physics. The first of them use entangled quantum resources such as cluster states, which are useful to demonstrate verifiable quantum advantages based on sampling problems (Theory proposal Phys. Rev. X 8, 021010, 2018 and recent experimental demonstration arXiv preprint arXiv:2307.14424). The second probe measurement of many-body quantities such as dynamical structure factors in quantum simulation setups (Proceedings of the National Academy of Sciences 117 (42), 26123-26134).

CONTROLLING ULTRACOLD MOLECULES FOR QUANTUM SCIENCE

GIACOMO VALTOLINA, FRITZ HABER INSTITUT BERLIN

Ultracold molecules hold great potential for future quantum technologies but their complexity has so far hampered their development. In this presentation, I will cruise through recent development in the fields that have enabled the attainment of the first quantum degenerate gases of molecules, that opens exciting opportunities for the future.

GENERATION AND USE OF HIGHLY ENTANGLED PHOTONS FROM GAAS QUANTUM DOTS

ARMANDO RASTELLI, JOHANNES KEPLER UNIVERSITY (JKU) LINZ- ONLINE TALK

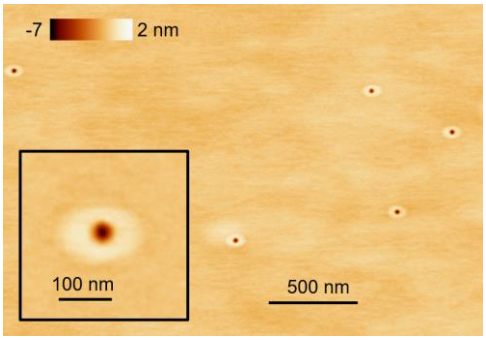

Figure 1 – Atomic force microscopy of a template of nanoles obtained by Al droplet etching on an AlGaAs surface. After filling with GaAs and AlGaAs ovegrowth, GaAs QDs are obtained.

Entanglement is one of the most peculiar phenomena in quantum science and a key resource for quantum technologies. More than two decades after the initial proposal [1], semiconductor quantum dots (QDs) are now beginning to outperform other light sources for the generation of entangled photon pairs.

Among different material systems, QDs in the (Al)GaAs material platform have demonstrated the highest degree of polarization entanglement to date together with other appealing features for quantum science and technology [2–4]. These QDs are obtained by GaAs overgrowth of an AlGaAs surface with nanoholes (see Fig. 1) and are characterized by small inhomogeneous broadening, high oscillator strengths, shape with high in-plane symmetry, and high optical quality, especially when embedded in charge-tunable diode structures. In this talk, we will discuss the properties of GaAs QDs obtained by the droplet etching method [5] and present recent results relevant to their application in quantum communication, such as entanglement-based quantum key distribution [6], as well as open challenges [7].

References

[1] O. Benson, C. Santori, M. Pelton and Y. Yamamoto, *Regulated and Entangled Photons from a Single Quantum Dot*, Phys. Rev. Lett. 84, 2513–2516 (2000).

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[3] L. Zhai, G. N. Nguyen, C. Spinnler, J. Ritzmann, M. C. Löbl, A. D. Wieck, A. Ludwig, A. Javadi and R. J. Warburton, *Quantum interference of identical photons from remote GaAs quantum dots*, Nat. Nanotechnol. 17, 829–833 (2022).

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