Q 11: Quantum Technologies II

Time: Monday 16:30–18:00 Location: Q-H13

Invited Talk Q 11.1 Mon 16:30 Q-H13

Quantum-state engineering with optically-trapped neutral atoms — •Vladimir M. Stojanovic, Gernot Alber, Thorsten Haase, and Sascha H. Hauck — Institut für Angewandte Physik, Technical University of Darmstadt, Germany

Recent years have seen tremendous experimental progress in the realm of optically-trapped neutral atoms. In this talk, three theoretical proposals for quantum-state engineering in this type of systems will be presented. It will first be demonstrated that a deterministic conversion of a three-qubit W state into its Greenberger-Horne-Zeilinger counterpart can efficiently be carried out in the Rydberg-blockade regime of neutral-atom systems using a dynamical-symmetry-based approach. It will then be shown that a W-type entanglement can be engineered in arrays of neutral atoms with Rydberg-dressed resonant dipole-dipole interaction. Finally, a time-efficient control scheme for coherent single-atom transport in moving optical lattices (optical conveyor belts and double-well lattices) – based on the enhanced shortcuts-to-adiabaticity approach – will be described.

Q 11.2 Mon 17:00 Q-H13

Fabrication of NbTiN Superconducting Nanowire Single-Photon Detectors using Helium-Focused Ion Beam — •Matthias D. Kurschner, Martin A. Wolff, Lisa Sommer, Matvey Lyatti, and Carsten Schuck — Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Superconducting nanowire single-photon detectors (SNSPDs) have shown to be the detector technology of choice for single photon counting experiments as they offer high repetition rate, high quantum efficiency, low time jitter and low dark count rates [1]. However, current fabrication methods employ e-beam lithography and dry etching in order to realize nanowire geometries in a top-down approach, which limits the resolution and suffers from proximity effects. In this work, we introduce state-of-the-art focused helium ion beam (HE-FIB) milling for the fabrication of niobium titanium nitride (NbTiN) nanowires. Moreover, we use automated patterning capabilities to achieve scalable fabrication of larger numbers of devices on a chip. We assess the damage nanowires may incur when exposed to helium ions and investigate the effective width and length of the manufactured nanowires. We compare results with HI-FIB milling with more established patterning techniques using a gallium FIB. We further realize long meander-shaped wires connected in series with the photosensitive nanowire for controlling the kinetic inductance, which allows realizing SNSPDs with wider nanowire width.

[1] S. Ferrari et al., Nanophotonics, 7, 1725 (2018)

Q 11.3 Mon 17:15 Q-H13

Argon Trap Trace Analysis - an applied Quantum Technology — •Julian Robertz[1], Yannis Arck[2], David Wachs[1,2], Florian Meienburg[1,2], Werner Aeschbach[2,3], and Markus Oberthaler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute of Environmental Physics, Heidelberg, Germany — [3]Heidelberg Center for the Environment, Heidelberg, Germany

Environmental tracers serve as an important source of information in a wide range of sciences. Due to the low relative abundance of some of these tracers an ultra-sensitive detection technique is necessary. In the case of the environmental tracer ^{39}Ar the Argon Trap Trace Analysis (ArTTA) allows us to measure relative abundances in the range of 10^{-16}. The isotopic shift in the resonance frequency together with multiple resonant scattering processes grants perfect selectivity. Single atoms are captured and identified in a magneto-optical trap (MOT), while the huge background of abundant isotopes remains unaffected.

This ultra-sensitive Quantum Technology was successfully used to study groundwater, lake, ocean and ice samples. Resulting requirements on ArTTA as well as (fundamental) limits will be discussed.

Q 11.4 Mon 17:30 Q-H13

Epitaxial growth of InP-based 1.3 micrometer quantum dots — •Vinayakrishna Joshi, Sven Bauer, Vitalii Sichkovskyi, Kerstin Fuchs, and Johann Reithmaier — Technische Physik, Institute of Nanostructure Technologies and Analytics (INA), CINSaT, University of Kassel Kassel, Germany

The transmission bands for medium to long range data communication are centered at 1.3 and 1.55 micrometer. The InAs/GaAs material system is widely researched at 1.3 micrometer[1], but 1.55 micrometer is hard to accomplish. Contrary, InP and InAs have a smaller lattice mismatch, which enables emission at 1.55 microns and already has been playing a dominant role. Compared to GaAs, InP devices allows higher frequency response and also has a higher modal gain. Therefore, to cover also the 1.3 micrometer regime, a strongly modified growth process is needed.

The structures were grown on S-doped InP (100) substrates, starting with a thick InP buffer layer, followed by InAlGaAs barrier layer. The active layer of 3 ML thick InAs QDs was grown. This was capped by another InAlGaAs layer. To achieve lasing at 1.3 microns, the QDs were grown on a nucleation layer which enables in creating more nucleation points for the QDs. This new type of QD gain material processed into broad area and ridge waveguide lasers. Static characterization data showed a high modal gain of about 15 cm-1 per quantum dot layer similar to 1.55 micrometer high-performance QD lasers [2]. [1]*M. Suguwara, et al., Journal of Applied Physics 97 (2005) [2]*S. Bauer et al., IEEE Nanotechnology Magazine 23 (2021)

Q 11.5 Mon 17:45 Q-H13

Cryogenic Fiber-based Fabry-Pérot Microcavities — •Timon Eichhorn[1], Maximilian Pallmann[1], Thomas Hümmer[2], and David Hunger[1] — [1]Karlsruher Institut für Technologie, Karlsruhe, Germany — [2]Qlibri Projekt, Fakultät für Physik, Ludwig-Maximilians-Universität München, Germany

One of the fundamental challenges in realizing optical quantum technologies is to have an efficient light-matter interface. A promising approach therefore is to use fiber-based Fabry-Pérot microcavities due to their high cooperativities and large coupling efficiencies into single-mode optical fibers [1]. For the sake of good coherence properties of the quantum emitters, systems have to be cooled down to cryogenic temperatures. During the past decade, much effort was put into the development of cryo-compatible microcavity stages. The noisy environment in closed-cycle cryostats poses the biggest challenge to operate such fully tunable open microcavities. Here, we present our achievements regarding the operation of high-finesse scanning cavities with cavity length stabilities of down to 1pm rms and full 3-axis tunability at cryogenic temperatures in closed-cycle and flow cryostats. [1] New J. Phys. **12** (2010) 065038