QI 1: Implementations: Atoms, Ions and Photons

Time: Monday 10:45–12:45 Location: H4

Invited Talk QI 1.1 Mon 10:45 H4

TBA — •Christine Silberhorn — Universität Paderborn, Fakultät für Naturwissenschaften, Department Physik - Angewandte Physik, 33095 Paderborn, Germany

TBA

Invited Talk QI 1.2 Mon 11:15 H4

TBA — •Jonathan Home — ETH Zürich, Department of Physics, Otto-Stern-Weg 1, 8093 Zürich, Switzerland

TBA

QI 1.3 Mon 11:45 H4

Superconducting Nb-based plasmonic perfect absorbers for tunable near- and mid-IR photodetection — •Philipp Karl[1], Sandra Mennle[1], Monika Ubl[1], Ksenia Weber[1], Mario Hentschel[1], Philipp Flad[1], Jing-Wei Yang[2,3], Yu-Jung Lu[2,3], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan — [3]Department of Physics, National Taiwan University, Taipei 10617, Taiwan

Quantum technologies require the provision of high-quality and efficient photodetectors, as well as the ability to detect single photons, which can be provided by superconducting nanowire single photon detectors. To reach near-100% absorption with our structures we are utilizing resonant plasmonic perfect absorber effects. This is aided by the angle insensitivity and the high resonant absorption cross section and of plasmonic resonances, which enable ultra-small active areas and short recovery times. In this work, we present simulations as well as measurements of tunable superconducting niobium based plasmonic perfect absorber structures with near-100% absorption efficiency in the infrared spectral range and use the tunable plasmonic resonance to create a polarization dependent photodetector. To demonstrate the resonant plasmonic behavior, which manifests itself through a polarization dependence detector response, we investigated the detector structure with an external light source, as well as with a directly coupled single mode fiber.

QI 1.4 Mon 12:00 H4

Towards a fault-tolerant universal set of microwave driven quantum gates with trapped ions — •Nicolas Pulido[1,2], Markus Duwe[1,2], Hardik Mendpara[1,2], Amado Bautista[1,2], Giorgio Zarantonello[3], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]PTB, Bundesallee 100, 38116 Braunschweig — [3]National Institute of Standards and Technology, Boulder, Colorado 80303

A fully operational quantum computer will require a complete set of quantum gates, with sufficiently low gate-errors to allow fault tolerance [1]. Here, we consider the implementation of single- and two-qubit gates using microwaves [2] as a scalable alternative to the more widely spread optical addressing techniques, which are typically limited by photon scattering. The control fields are generated by microwave conductors embedded directly into the trap structure. We obtain a preliminary infidelity of 10^{-4} for single-qubit gates and approaching 10^{-3} for two-qubit operations using this fully integrated approach. The two-qubit gates are shown to be robust with respect to motional quantum bus noise as a result of a tailored amplitude modulation protocol [3].

[1] E. Knill et al., Nature 434, 39-44 (2005)
[2] C. Ospelkaus et al., Phys. Rev. Lett. 101 090502 (2008)
[3] G. Zarantonello et al., Phys. Rev. Lett. 123 260503 (2019)

QI 1.5 Mon 12:15 H4

Tunable magnetic quadrupole for MAGIC-based quantum information processing in a planar electrode ion trap — •Ivan Boldin, Elham Esteki, Bogdan Okhrimenko, and Christof Wunderlich — University of Siegen, Siegen, Germany

Magnetic gradient induced coupling (MAGIC) is an approach to quantum information processing with trapped ions, where all coherent operations with qubits are carried out with microwave-frequency electromagnetic fields. This approach requires a strong static magnetic field gradient along the chain of trapped ions. Such a static gradient can either be created by electric currents or by permanent magnets. Electric currents are tunable, but it is hard to reduce the current noise to a sufficiently low level. Permanent magnets can provide a strong field gradient with low noise, but the field cannot be tuned. We have come up with a solution to the abovementioned challenge: a system that is free from electrical currents during quantum logic operations, and which creates a fully tunable strongly inhomogeneous magnetic field. This is achieved by the use of a permanent magnet quadrupole made of moderate coercivity material (AlNiCo) that can be magnetized (and demagnetized) by short current pulses. We present the results of experimental characterization of our novel type of magnetic quadrupole. Using trapped Yb ions as a magnetic field sensor, we demonstrate a maximum gradient of 116 T/m and the tunability of the field. In addition, we present the results of the investigation of the coherence properties of the trapped-ion based qubits, depending on the magnetic field gradient.

QI 1.6 Mon 12:30 H4

Real-time capable CCD-based individual trapped-ion qubit measurement — •Sebastian Halama[1], Timko Dubielzig[1], Niklas Orlowski[1], Celeste Torkzaban[1], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Physikalisch-Technische-Bundesanstalt, Bundesallee 100,0 38116 Braunschweig, Germany

We report on the individual detection of $^{9}Be^{+}$ qubit states undergoing coherent excitation using an EMCCD camera. The ions are trapped in a cryogenic surface-electrode ion trap with integrated microwave conductors [1] for near-field quantum control. This kind of trap promises good scalability to a higher number of qubits [2]. Together with the individual real-time detection this is a key requirement for many-body quantum simulation and also error-correction protocols in quantum information processing [3]. We discuss known error sources during state preparation and measurement in the order of 0.5 % and comment on the sources and the amount of crosstalk in our detection system. We briefly present the used imaging system and compare the qubit state detection performance of the EMCCD camera with a PMT.

[1] Dubielzig et. al., Rev. Sci. Instr. **92**, 043201 (2021)
[2] Kielpinski et. al., Nature **417**, 709 (2002)
[3] Nielsen and Chuang, Quantum Computation and Quantum Information, Cambridge (2000)