Q 33: Quantum Information: Solid State Systems II

Time: Wednesday 14:30–16:15 Location: P 3

Q 33.1 Wed 14:30 P 3

Quantum photonics with superconducting single-photon detectors on silicon chips — •Carsten Schuck[1,2], Xiang Guo[1], Linran Fan[1], Hojoong Jung[1], Xiaosong Ma[1], Menno Poot[1], Chang-Ling Zou[1], and Hong Tang[1] — [1]Department of Electrical Engineering, Yale University, New Haven, CT 06511, USA — [2]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany

Single photons in nanophotonic circuits on silicon chips hold great promise for scalable quantum information processing. Sources of non-classical light, integrated optical circuit components and waveguide-coupled single-photon detectors are essential ingredients of a photonic quantum processor. Here we report progress on realizing these components with standard semiconductor thin-film technology on silicon chips. We demonstrate quantum interference of photons from spontaneous parametric down conversion on an integrated directional coupler fabricated from nanophotonic silicon nitride waveguides. We observe two-photon interference with 97% visibility when measuring photon statistics with waveguide-coupled superconducting nanowire single-photon detectors directly on-chip [1]. Further we realize a spontaneous parametric down conversion source in micro-ring resonators made from aluminum nitride. Antibunching of heralded single-photons with high modal purity [2] highlights the suitability of this source for quantum information processing.

[1] Schuck te al., Nature Comm. 7, 10352 (2016).
[2] Guo te al., Light: Science & Applications 6, e16249 (2017).

Q 33.2 Wed 14:45 P 3

Optical quantum memories with colour centre ensembles in diamond — •Jonas Nils Becker[1], Christian Weinzetl[2], Johannes Görlitz[1], Eilon Poem[3], Joshua Nunn[2], Ian Alexander Walmsley[2], and Christoph Becher[1] — [1]Fakultät NT (Fachrichtung Physik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany — [2]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — [3]Weizmann Institute of Science, Rehovot 7610001, Israel

The reliable storage of a quantum state in the form of a photon without destroying its coherence properties remains a significant challenge in the field of quantum information processing. One scheme to realize such an optical quantum memory is a Raman-based storage in a dense ensemble of emitters via an off-resonant two-photon absorption of single photons, aided by a strong auxiliary control-field in a Λ-type configuration. In this scheme, the memory bandwidth is only limited by the ground state splitting of the ensemble. We here propose the use of an ensemble of silicon vacancy (SiV) colour centres in diamond as a storage medium to realize such a memory. A large ground state splitting of 48 GHz allows for storing picosecond photons over tens of nanoseconds enabling applications in e.g. deterministic single photon sources or buffer memories. We here present theoretical as well as first experimental results demonstrating the feasibility of an SiV-based memory as well as storage-time-extension using Hahn-Echo pulse sequences in inhomogeneously broadened ensembles.

Q 33.3 Wed 15:00 P 3

Optical coherence in 1.53 um Erbium transition in ^{7}LiYF$_4$ crystal below 1K — •Nadezhda Kukharchyk[1], Dmitriy Sholokhov[1], Stella L. Korableva[2], Alexey A. Kalachev[3], and Pavel Bushev[1] — [1]Experimentalphysik, Universität des saarlandes, D-66123 Saarbrücken, Germany — [2]Kazan Federal University, 420008 Kazan, Russian Federation — [3]Kazan Institute of Physics and Technology, 420029 Kazan, Russian Federation

Rare earth doped materials find nowadays many applications in various industrial and research fields. When put into wide band gap crystals, rare earths exhibit long optical and microwave coherence times, which is in a great interest for quantum information processing. In current work, we have studied Erbium monoisotopic LiYF$_4$ crystals. Such isotopically pure crystals have very low optical inhomogeneous broadening of approx. 10 MHz; This opens many possibilities to implement these crystals as off-resonant Raman quantum memory or as frequency converter. Here, we demonstrate dependencies of coherence times of ^{166}Er in ^{7}LiYF$_4$ on magnetic field and on temperature. Several crucial effects were observed: “frozen core” and ZEFOZ, which allowed to reach optical coherence times up to 75 us at magnetic field of 200 mT.

Q 33.4 Wed 15:15 P 3

Arbitrary n-Qubit State Transfer Using Coherent Control and Simplest Switchable Local Noise — Ville Bergholm[1], •Frank K. Wilhelm[2], and Thomas Schulte-Herbrüggen[1] — [1]Dept. Chemistry, Technical University of Munich (TUM), D-85747 Garching, Germany — [2]Institute for Theoretical Physics, University of Saarland, 66123 Saarbrücken, Germany

We study the reachable sets of open n-qubit quantum systems, the coherent parts of which are under full unitary control, with time-modulable Markovian noise acting on a single qubit as an additional degree of incoherent control. In particular, adding bang-bang control of amplitude damping noise (non-unital) allows the dynamic system to act transitively on the entire set of density operators. This means one can transform any initial quantum state into any desired target state. Adding switchable bit-flip noise (unital), on the other hand, suffices to explore all states majorised by the initial state. We have extended our open-loop optimal control package dynamo to also handle incoherent control so that these unprecedented reachable sets can systematically be exploited in experiments. We propose implementation by a GMon, a superconducting device with fast tunable coupling to an open transmission line, and illustrate how open-loop control with noise switching can accomplish all state transfers without the need for measurement-based closed-loop feedback schemes with a resettable ancilla.

Q 33.5 Wed 15:30 P 3

High-fidelity qbuit State Tomographie in the Nonlinear Dispersive Regime — •Marius Schöndorf[1], Luke C. G. Govia[1,2], and Frank K. Wilhelm-Mauch[1] — [1]Theoretical Physics, Saarland University, 66123 Saarbrücken, Germany — [2]Departement of Physics, McGill University, Montreal, Quebec, Canada H3A 2T8

Superconducting qubits are promising candidate for the realization of a scalable quantum computer. An important step for real implementations is qubit state tomography. In the past we presented a scheme to readout sinlge qubit states as well as multiple parities with a microwave photon counter. Especially parity readout plays an important role for the implementation of error correction codes. Since most of the existing microwave photon counters do not have very high efficiencies, such that it is necessary to increase contrast in the readout cavity.

In this work we theoretically describe multiple qubits dispersively coupled to a driven cavity. We are especially interested in the regime where the linear dispersive approximation breaks down, which means the photon number in the cavity exceeds a specific number $n > n_{\text{crit}}$. To get a valid theoretical description of that system we need to use the exact dispersive transformation, which is also valid for high cavity occupation. The result is a nonlinear behavior for high drive strengths which has a strong dependence on the state of the N qubits coupled to the cavity which leads to a very high contrast of about 10^5 photons in the cavity. We show that this can be used to perform various multi qubit measurements with very high fidelity.

Q 33.6 Wed 15:45 P 3

Robust quantum optimizer with full connectivity — Simon Nigg, •Niels Lörch, and Rakesh Tiwari — Departement Physik, Universität Basel, Schweiz

Quantum phenomena have the potential to speed up the solution of hard optimization problems. For example quantum annealing, based on the quantum tunneling effect, has recently been shown to scale exponentially better with system size as compared with classical simulated annealing. However, current realizations of quantum annealers with superconducting qubits face two major challenges. First, the connectivity between the qubits is limited, excluding many optimization problems from a direct implementation. Second, decoherence degrades the success probability of the optimization. We address both of these shortcomings and propose an architecture in which the qubits are robustly encoded in continuous variable degrees of freedom. Remarkably, by leveraging the phenomenon of flux quantization, all-to-all connectivity is obtained without overhead. Furthermore, we demonstrate the robustness of this architecture by simulating the optimal solution of a small instance of the NP-hard and fully connected number partitioning problem in the presence of dissipation.

Reference: arXiv:1609.06282

Q 33.7 Wed 16:00 P 3

Non-Markovianity in driven open quantum systems — •Rebecca Schmidt[1,2,3], Tapio Ala-Nissilä[3,4], and Sabrina Maniscalco[1,2] — [1]Turku Centre for Quantum Physics, Department of Physics and Astronomy, University of Turku, FIN-20014 Turku, Finland — [2]Center for Quantum Engineering, Department of Applied Physics,Aalto University School of Science, P.O. Box 11000, FIN-00076 Aalto, Finland — [3]COMP Center of Excellence, Department of Applied Physics, Aalto University, P.O. Box 11000, FI-00076 Aalto, Finland — [4]Department of Physics, P.O. Box 1843, Brown University, Providence, Rhode Island 02912-1843, U.S.A.

Open system dynamics inevitably experience losses in particular in strongly coupled systems such as condensed matter devices. However, it has be shown that non-Markovian dynamics give rise to information backflow. Here we show, how driving changes this information backflow as well as if and how tailored driving can use information backflow as a resource.